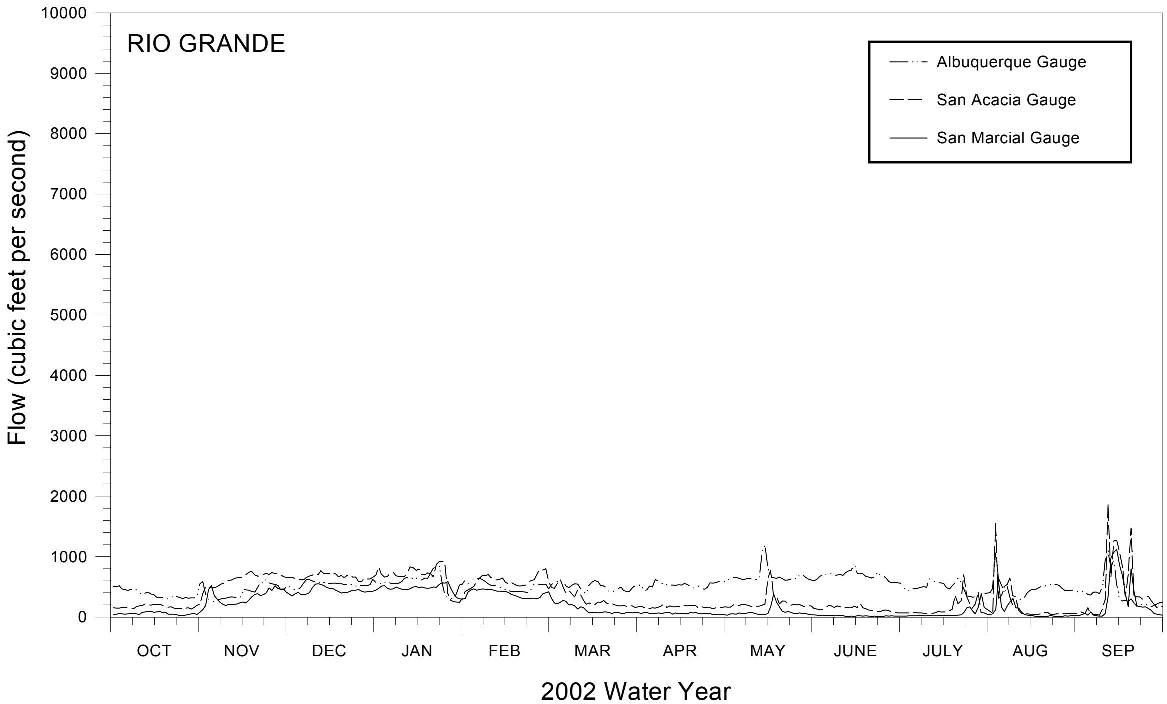
2002 Population Monitoring of Rio Grande Silvery Minnow, *Hybognathus amarus*

Final Report



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and Steven P. Platania

American Southwest Ichthyological Research Foundation

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EXECUTIVE SUMMARY

Rio Grande silvery minnow, *Hybognathus amarus*, has been declining in distribution and abundance in the Rio Grande during the past fifty years. The remaining population of the endemic cyprinid resides in a 280 km reach of river between Cochiti Dam and Elephant Butte Reservoir in the Middle Rio Grande of New Mexico. The remnant population of this once widespread species has been steadily declining in abundance since its listing as a federal endangered species in 1994. Multiple pronounced river drying events over the past decade have eroded the ability of this species to recover in its current range. In addition, fragmentation of its remaining range into four segments (35.9, 65.2, 85.5, and 90.4 km long) by diversion dam structures (Angostura, Isleta, and San Acacia) pose continued threats to the long-term persistence of this species.

Population monitoring efforts of the fish community in the Middle Rio Grande show that Rio Grande silvery minnow catch rates declined significantly ($p<0.01$) from 1993 to 2002. The number of Rio Grande silvery minnow taken in 2002 was not only very low in each of the three reaches, but had declined to the lowest levels ever recorded (<1 individual/1,000 m^2) by October 2002. In 2002, the San Acacia Reach yielded the most silvery minnow, followed by the Isleta Reach, and the Angostura Reach. Monthly catch rates of this endangered cyprinid decreased significantly ($p<0.01$) in each of the reaches during 2002.

Analysis of Rio Grande silvery minnow catch rates revealed a significant interaction ($p<0.01$) between mean catch rate and locality. The highest catch rates of Rio Grande silvery minnow were generally recorded at upstream sampling localities in each of the respective reach (i.e, close to diversion dams). This spatial distribution of individuals was most pronounced in the Isleta and San Acacia reaches.

River discharge during 2002 was artificially elevated through a short duration reservoir release during May 2002 to induce spawning by Rio Grande silvery minnow. Although a large number of Rio Grande silvery minnow eggs were released as a result of the flow spike, the production of propagules ultimately failed to result in recruitment of many silvery minnow to the 2002 year-class. In fact, young-of-year individuals comprised an unusually small percentage of the total Rio Grande silvery minnow catch following spawning in May and their abundance had rapidly declined by June 2002.

The cumulative effects of years of river drying, downstream displacement, and habitat degradation continue to be manifested by the decline of Rio Grande silvery minnow. The marked and alarming declines in abundance of Rio Grande silvery minnow recorded in 2002 during this population monitoring study provide the strongest evidence that the problems that led to the precipitous decline of this species have not been remedied. A renewed focus on issues that directly affect the immediate survival of this species in the wild is essential. Removal of instream barriers that prevent Rio Grande silvery minnow from repopulating upstream reaches, the need to maintain increased and variable flow throughout downstream reaches, and restoration and reconnection of the historical floodplain are paramount issues that need to be resolved to assure the continued persistence of this species.

INTRODUCTION

Population information on Rio Grande silvery minnow and the associated Middle Rio Grande (Rio Grande between Velarde and Elephant Butte Reservoir, New Mexico) fish community has been gathered regularly since 1987. The first studies were conducted by Platania (1993a) from 1987-1992 to determine spatial and temporal changes in the Middle Rio Grande ichthyofaunal community and provide resolution of species-specific habitat use patterns. A key purpose of those preliminary studies was also to supply additional information on the conservation status of Rio Grande silvery minnow. Quarterly sampling efforts during 1989 and 1990 revealed that silvery minnow population numbers were extremely low. Based on previous samples, these low numbers indicated a rapid decline of this species in its already greatly reduced range. The 90-95% reduction in the range of silvery minnow and threats to its continued persistence in the Middle Rio Grande were central to this species being listed as endangered by the U. S. Fish and Wildlife Service (U. S. Department of Interior, 1994).

From 1992 until the present, the U. S. Bureau of Reclamation, U. S. Fish and Wildlife Service, New Mexico Department of Game and Fish, and U. S. Corps of Engineers have cooperated to fund numerous ichthyofaunal studies in the Middle Rio Grande. Among these studies was long-term monitoring of the distribution and relative abundance of the Middle Rio Grande fish community at numerous sites between Angostura Diversion Dam and Elephant Butte Reservoir (initiated in 1993). While Rio Grande silvery minnow was the primary focus of most efforts, the research activities were also designed to provide information about the entire fish community.

The objective of the 2002 collecting activities was to monitor populations of Rio Grande silvery minnow and the associated fish community in the Middle Rio Grande, New Mexico. Seasonal and spatial differences in population structure and species abundances of Middle Rio Grande fishes were examined. Annual changes in the distribution, abundance, and composition of all fish species were also assessed. Information obtained from this study will allow a more thorough understanding of the current conservation status and population dynamics of Rio Grande silvery minnow, both of which are important components for the recovery of this species.

STUDY AREA

The headwaters of the Rio Grande are located in the San Juan Mountains of southern Colorado. The mainstem Rio Grande flows 750 km through New Mexico draining an area of about 68,104 km^2 (excluding closed basins). The Rio Chama is the only major perennial tributary of the Rio Grande in New Mexico and confluences with it near the city of Española. Snowmelt from southern Colorado and northern New Mexico provides the majority of water for the Rio Grande, but transmontane diversions from the San Juan River drainage (Colorado River Basin) supplement flow. The highest flow in the Rio Grande generally occurs during spring snowmelt, while the lowest flow usually occurs in late summer and autumn. Low flow in the river from March through October is caused, in part, by diversions into irrigation canals. Summer thunderstorms periodically augment low flow in discrete reaches, but do not ensure that the river channel will remain wetted. Precipitation in the region is low and averages <25 cm/year (Gold and Denis, 1985).

The Middle Rio Grande is defined as the reach between Velarde, New Mexico and Elephant Butte Reservoir (Figure 1). This reach changes considerably through its 364 km length. At high elevations, the Middle Rio Grande is a narrow, canyon-bound coldwater river with large substrata and a salmonid-dominated fish community. In contrast, downstream areas are 50-250 m wide, sand-bottomed, and support a warmwater fish community. The area of interest of this study is a segment of the Middle Rio Grande and encompasses the current range of Rio Grande silvery minnow (i.e., below Cochiti Dam to the inflow of Elephant Butte Reservoir). The Cochiti Reach of the Rio Grande (between Cochiti Dam and Angostura Diversion Dam) passes first through Cochiti Pueblo, then Santo Domingo Pueblo, and finally San Felipe Pueblo; access is currently restricted in this reach precluding

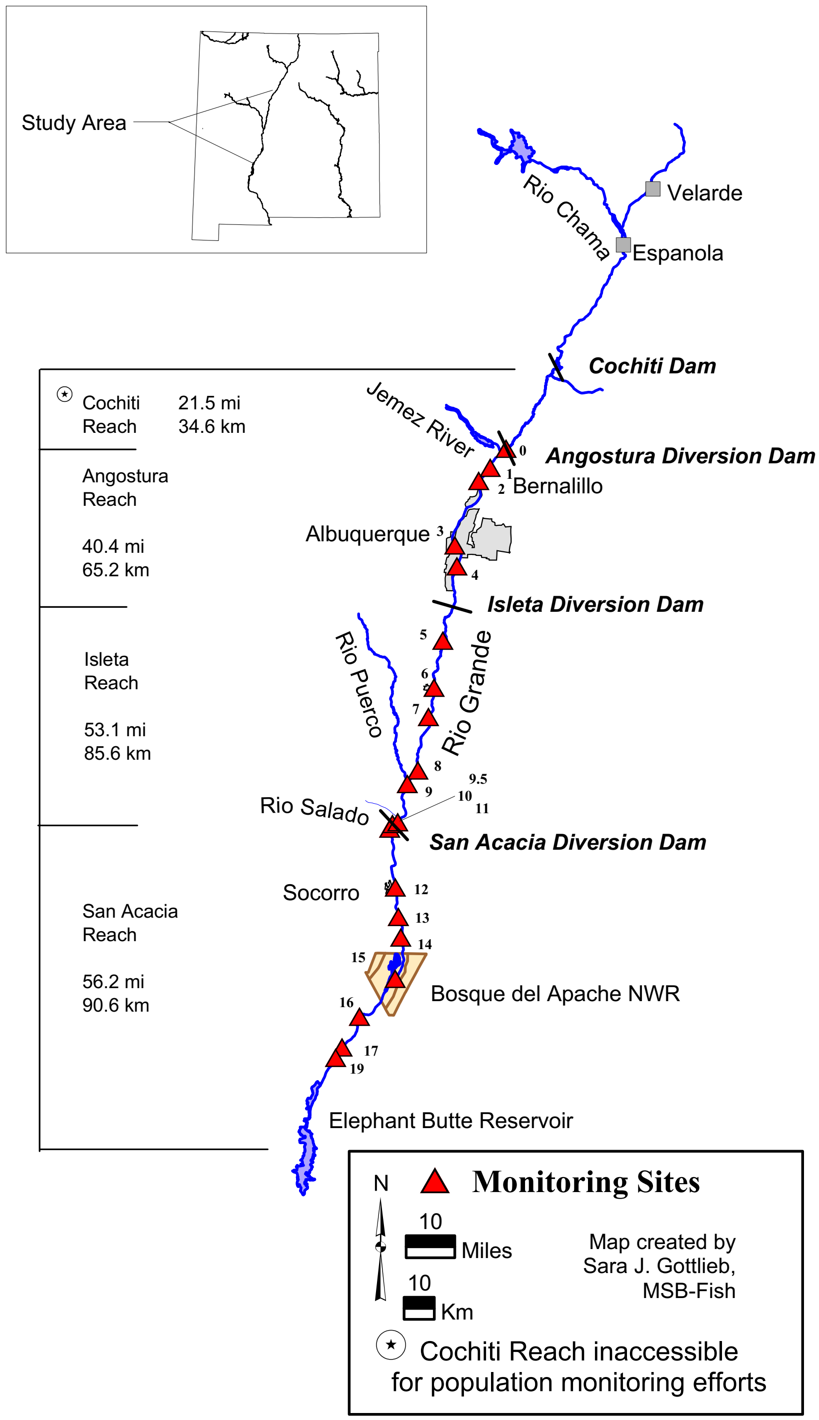

Figure 1. Map of the Middle Rio Grande and study area.

fish sampling for this study. The last comprehensive ichthyofaunal surveys of the Rio Grande in the Cochiti Reach documented the presence, at low abundance, of Rio Grande silvery minnow on Santo Domingo and San Felipe pueblos (Platania, 1995). Rio Grande silvery minnow were not taken within the boundaries of Cochiti Pueblo (Platania, 1993b).

Flow in the Rio Grande is regulated by five mainstem reservoirs on the rios Chama and Grande and numerous smaller irrigation diversion dams throughout the drainage. The complex system of ditches, drains, and conveyance channels provide water for extensive irrigated agriculture in the Rio Grande Valley. Cochiti Reservoir, located 76 km above Albuquerque and operational since 1973, is the primary flood control reservoir and largely regulates flow in the mainstem of the Middle Rio Grande.

The section of river from Angostura Diversion Dam to Bernalillo is a transition zone where the river channel becomes more braided, the floodplain widens, and substrata is primarily sand and silt. From Bernalillo downstream to Albuquerque, the river channel often exceeds 100 m in width and lower velocity habitats are more common. Backwaters are more abundant in this reach than between Cochiti and Angostura Diversion dams and substrata larger than sand is generally rare.

Downstream of Albuquerque, the Rio Grande is a wide and meandering river with a predominantly sand substrata, high suspended silt load, and a broad variety of mesohabitats. The mainstem channel is generally wide (100-200 m), <1 m deep, and has a current velocity of <1 m/s. From approximately the middle of Bosque del Apache National Wildlife Refuge to Elephant Butte Reservoir, the river channel is generally less than 50 m wide.

Diel and seasonal discharge varied but was consistently low during 2002 (Figures 2-3). Flow was generally lower at downstream (i.e., U. S. Geological Survey (USGS) San Acacia Gauge [#08354900] and USGS San Marcial Gauge [#08358400]) versus upstream locations (i.e., USGS Albuquerque Gauge [#08330000]). Flow was continuous in the Angostura Reach in 2002 but very low from July-October. From the middle of March 2002 until late October 2002, extremely low flow and occasional river drying persisted in the Isleta and San Acacia reaches. Summer rains occasionally supplemented low base flows and resulted in brief but elevated instream flow and turbidity levels.

METHODS

This study was structured to monitor populations of Rio Grande silvery minnow and associated fish community at selected sites (Appendix A, Table A-1) in the study area. Monthly sampling efforts allowed for determination of general spatial and temporal changes in population structure and species abundances. Sampling was conducted at 20 sites during each month of 2002 and posted on a U. S. Bureau of Reclamation maintained world-wide-web site (Appendix B). Site specific ichthyofaunal composition data were also posted at the aforementioned web site and are appended (Appendix C).

Reach names were derived from the diversion structure at the upstream boundary of that reach of river. The Angostura Reach (Angostura Diversion Dam to Isleta Diversion Dam) had five sampling localities and the Isleta Reach (Isleta Diversion Dam to San Acacia Diversion Dam) had six sampling sites. There were nine sampling localities in the San Acacia Reach (San Acacia Diversion Dam to Elephant Butte Reservoir). No sampling was conducted in the Cochiti Reach as this reach of the Rio Grande is sovereign property under the jurisdiction of at least three discrete Native American Pueblos and is not generally accessible.

Fish were collected by rapidly drawing a two-person 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through discrete mesohabitats (usually <15 m). During the spring and summer, a fine mesh (ca. 1.5 mm) seine was also used to selectively sample shallow low velocity habitats for larval fish. Nearly all fish >15 mm standard length (SL) were released at the site of capture. Retained fish (primarily larval individuals) were fixed in the field in 10% formalin and returned to the laboratory where they were sorted, identified to species, counted, measured (minimum and maximum SL), transferred to 70% ethyl alcohol, and catalogued into the Fish Division of the Museum of Southwestern Biology (MSB) at the University of New Mexico. Graphic illustration of fish catch per unit effort are provided

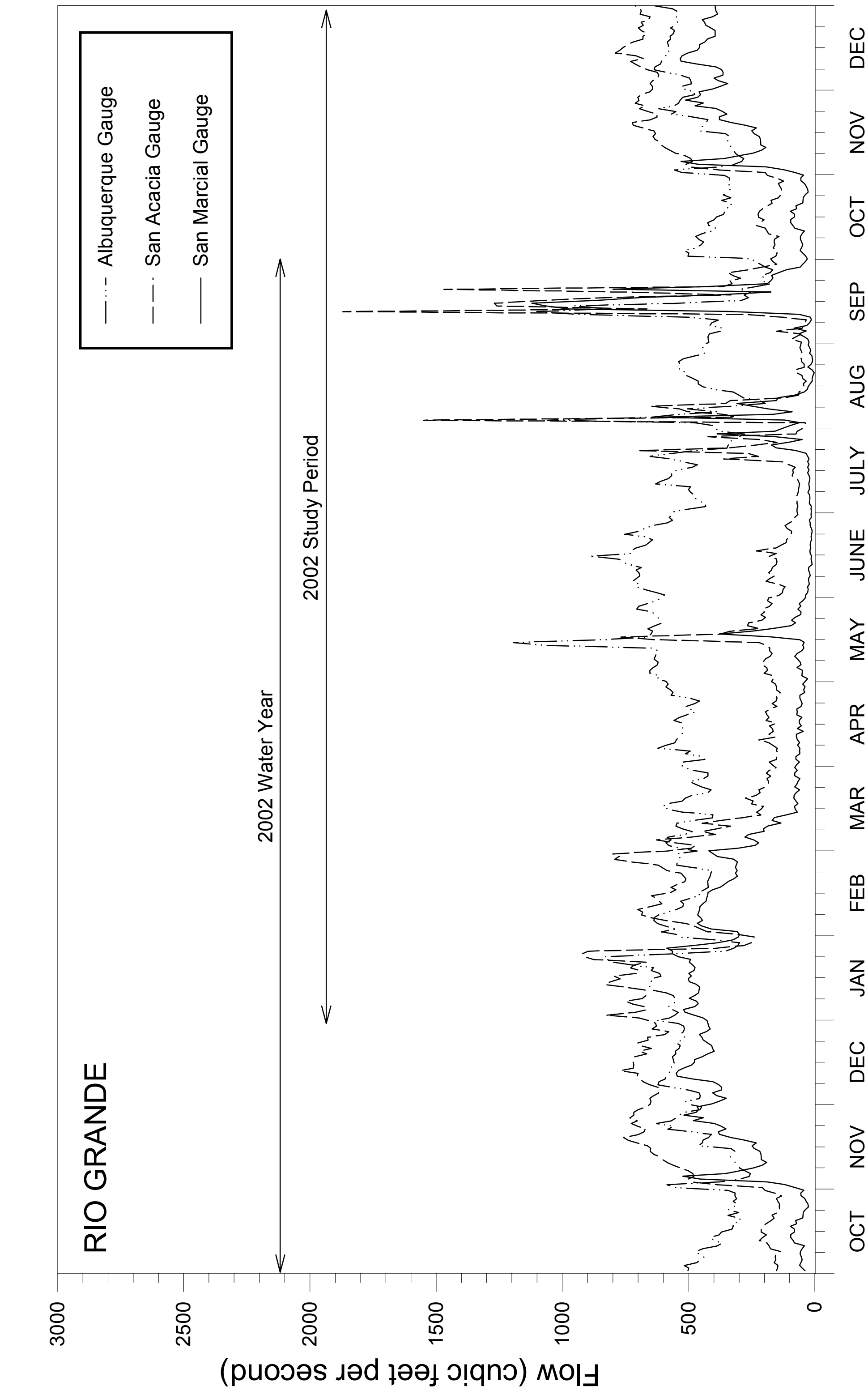

Figure 2. Hydrograph of the Rio Grande, NM at Albuquerque, San Acacia, and San Marcial during the 2002 water year and study period. (Note: Hydrological data are from the U. S. Geological Survey and are provisional).

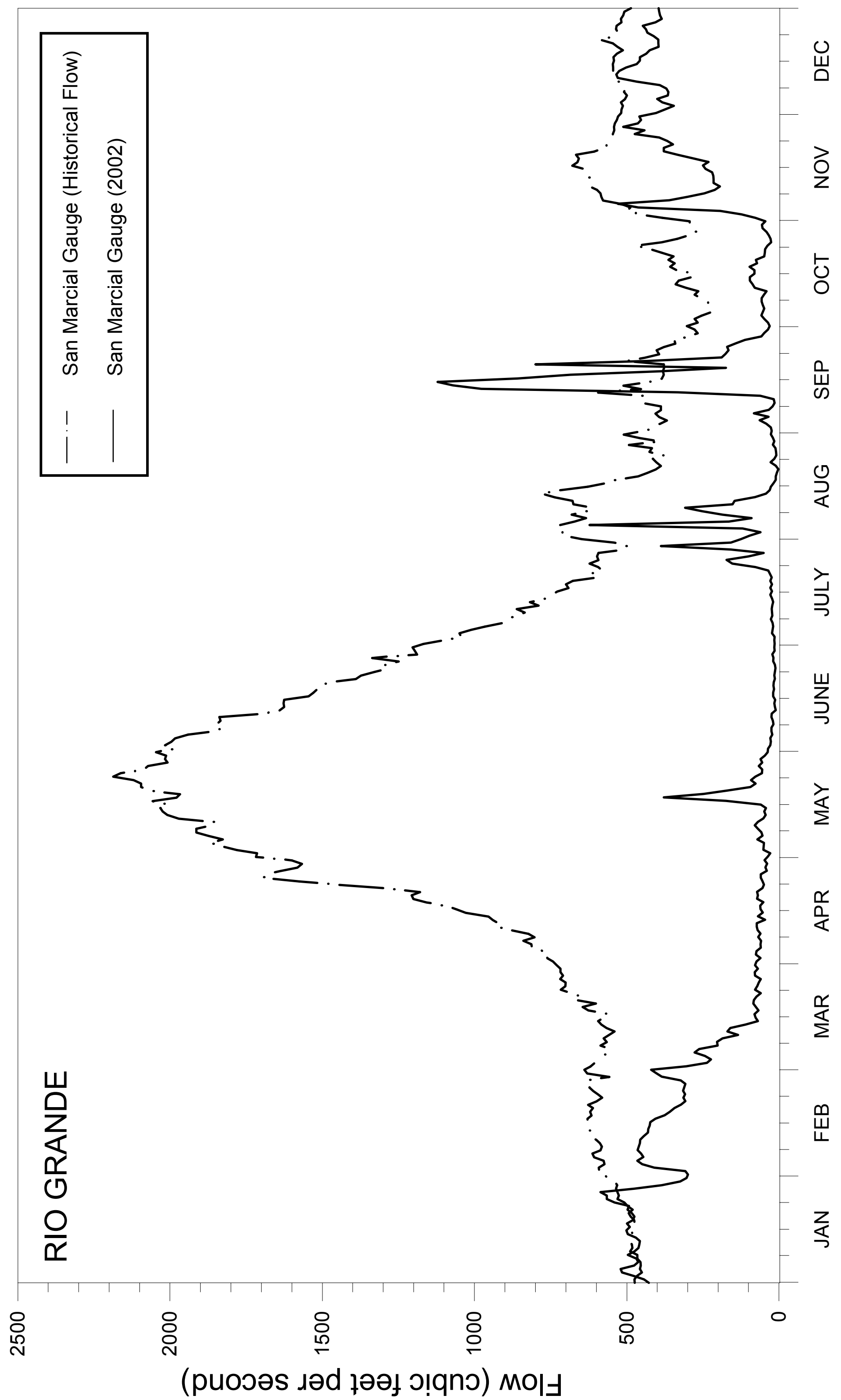

Figure 3. Hydrograph of the Rio Grande, NM at San Marcial based on historical mean daily flow data (52 yr.) and mean daily flow during 2002. (Note: Hydrological data are from the U. S. Geological Survey and are provisional).

for the 10 focal species (the 10 most common taxa that occur throughout the study area) for each collection locality by sampling period (Appendix A; Figures A-1 to A-7). Scientific and common names of fishes in this report generally follow Robins et al. (1991; Table 1). Common names, arranged in phylogenetic order, are used in tables and throughout this report.

Linear regression modeling of estimated abundance versus time was used to evaluate intra- and inter annual trends in population fluctuations. An analysis of trends in Rio Grande silvery minnow population levels, examined along temporal and spatial scales, was presented graphically and analyzed using monthly CPUE data for 20 sampling sites. Samples obtained from isolated pools were not included in data analysis as catch rates in these confined habitats were artificially elevated. Fish CPUE data from all samples were log-transformed ($X'=\log(X+1)$) based on low observed values and temporal heterogeneity of variance (Zar, 1984). A negative or positive trend in population abundance was defined as occurring when the slope of the regression was significantly different ($\alpha<0.05$) from zero. Two-factor analysis of variance without replication (Sokal and Rohlf, 1995) was also used to evaluate differences in mean catch rates between sampling sites over time.

RESULTS

Summaries of 2002 Monthly Collecting Activities

Rio Grande silvery minnow

The 2002 abundance of Rio Grande silvery minnow at reach-specific collection sites varied within and between seasons. Catch rate of silvery minnow also varied noticeably in and between sampling reaches (Figures 4-6). The San Acacia Reach generally produced the highest catch rates but even this river reach yielded markedly fewer silvery minnow in 2002 than during previous years.

Population monitoring efforts during January yielded the largest monthly cumulative catch of Rio Grande silvery minnow (n=548) during 2002 with the majority of individuals (n=341; 62.2%) taken in the San Acacia Reach. Rio Grande silvery minnow were present at 18 of 20 sampling localities during this sampling effort but sites in the upper portion of the Isleta and San Acacia reaches produced the greatest cumulative numbers of this species. The largest January 2002 collection of Rio Grande silvery minnow (n=109) was at the site immediately downstream of San Acacia Diversion Dam.

A total of 351 seine hauls were made during the February 2002 sampling trip of which 90 contained Rio Grande silvery minnow. All three sampling reaches yielded Rio Grande silvery minnow during the February sampling effort but catch rates for this species were very low at the majority of sites sampled (e.g., <10 individuals collected at 12 of 18 sites). The pattern of increased catch rate of Rio Grande silvery minnow at sampling sites located in the upper portion of the discrete river reaches, as noted in January 2002, was also observed in February 2002.

Population monitoring sampling in March 2002 resulted in the collection of Rio Grande silvery minnow at 13 of 20 collecting localities. The highest catch rate was recorded at the site immediately downstream of San Acacia Diversion Dam. Rio Grande silvery minnow was absent from collections made at the lowest-most sampling sites in each of the three river reaches. The distended abdomens of female Rio Grande silvery minnow taken in several collections during the March 2002 sampling trip suggested the development and ripening of eggs.

Fewer Rio Grande silvery minnow were collected in April 2002 (n=128) than March 2002 (n=167). The highest catch rate of this species was in the Isleta Reach with most sites in the San Acacia Reach producing <10 silvery minnow. Rio Grande silvery minnow was not collected in the Angostura Reach during the April 2002 sampling effort.

Population monitoring in May 2002 occurred soon after peak Rio Grande silvery minnow spawning (initiated by the early-May artificial flow spike). The cumulative number of individual silvery minnow collected in May 2002 (n=142) was similar to that taken during April 2002 (n=128). Catch rates of Rio Grande silvery minnow in May 2002 were, as in April 2002, highest in the Isleta Reach.

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande during 2002.

Scientific Name	Common Name	Code
Order Clupeiformes		
Family Clupeidae	herrings	
Dorosoma cepedianum	gizzard shad	(GZS)
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Cyprinella lutrensis	red shiner	(RDS)
Cyprinus carpio	common carp	(CCA)
Gila pandora	Rio Grande chub	(RGC)
Hybognathus amarus	Rio Grande silvery minnow	(RGM)
Pimephales promelas	fathead minnow	(FHM)
Platygobio gracilis	flathead chub	(FHC)
Rhinichthys cataractae	longnose dace	(LND)
Family Catostomidae	suckers	
Carpiodes carpio	river carpsucker	(RCS)
Catostomus commersoni	white sucker	(WHS)
Ictiobus bubalus	smallmouth buffalo	(SMB)
Order Siluriformes		
Family Ictaluridae	bullhead catfishes	
Ameiurus melas	black bullhead	(BBH)
Ameiurus natalis	yellow bullhead	(YBH)
Ictalurus punctatus	channel catfish	(CCT)
Order Cyprinodontiformes		
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(MOS)
Order Perciformes		
Family Percichthyidae	temperate basses	
Morone chrysops	white bass	(WHB)

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande during 2002 (continued).

Scientific Name	Common Name	Code
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(GNS)
Lepomis macrochirus	bluegill	(BGL)
Micropterus salmoides	largemouth bass	(LMB)
Pomoxis annularis	white crappie	(WCR)
Family Percidae	perches	
Perca flavescens	yellow perch	(YWP)
Stizostedion vitreum	walleye	(WLE)

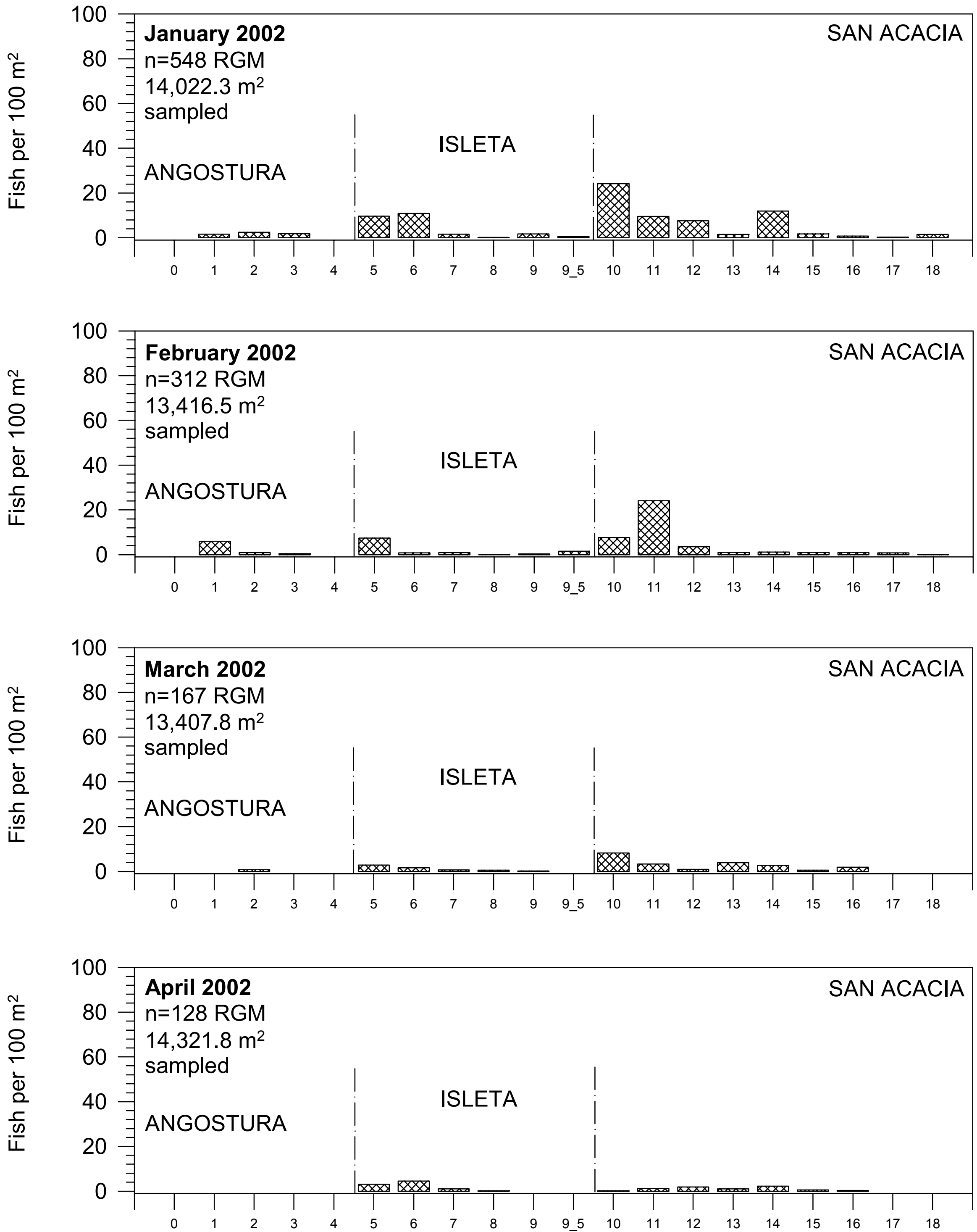

Figure 4. Rio Grande silvery minnow (RGM) catch rates (CPUE) from January-April 2002 for each collection locality in the Middle Rio Grande.

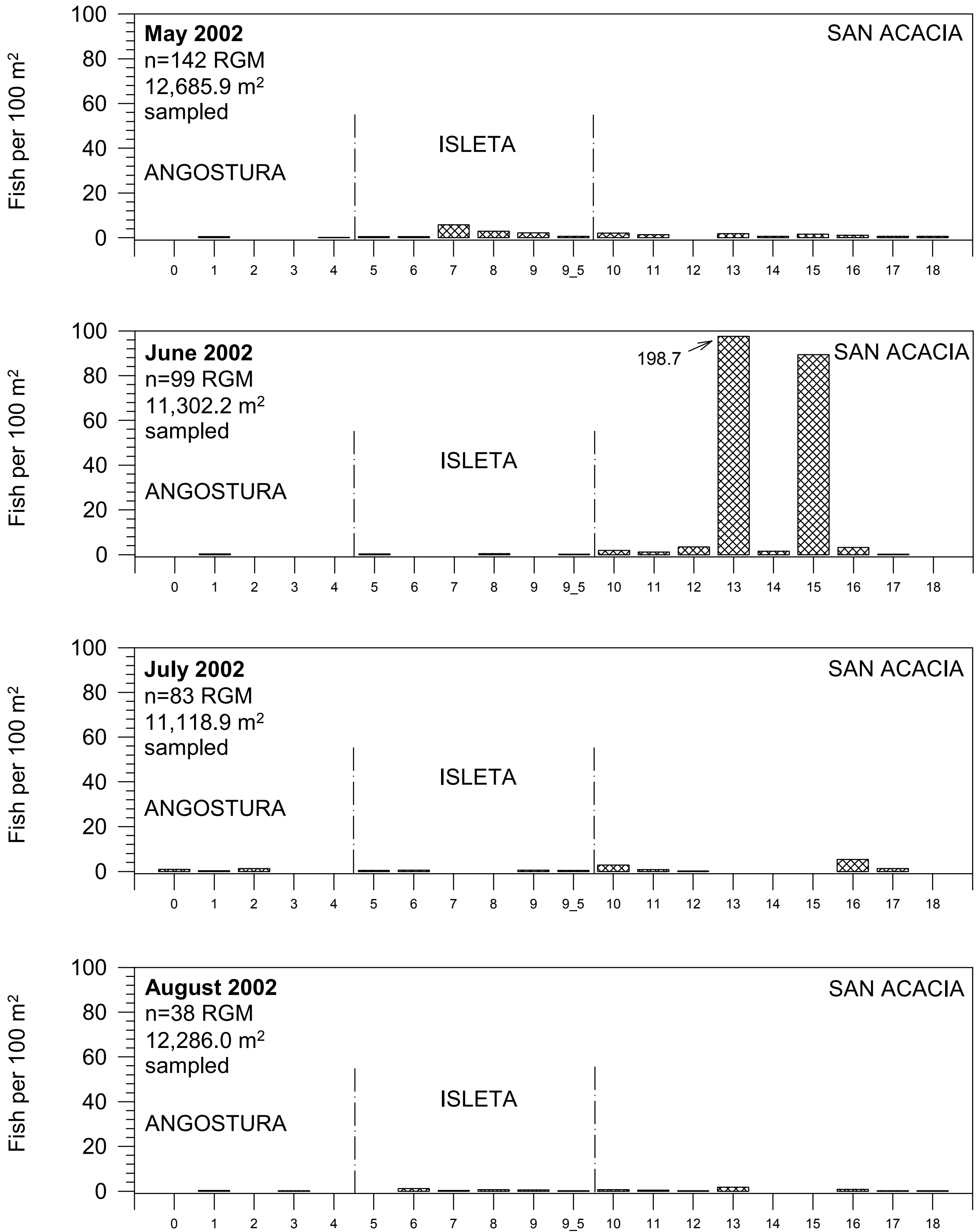

Figure 5. Rio Grande silvery minnow (RGM) catch rates (CPUE) from May-August 2002 for each collection locality in the Middle Rio Grande.

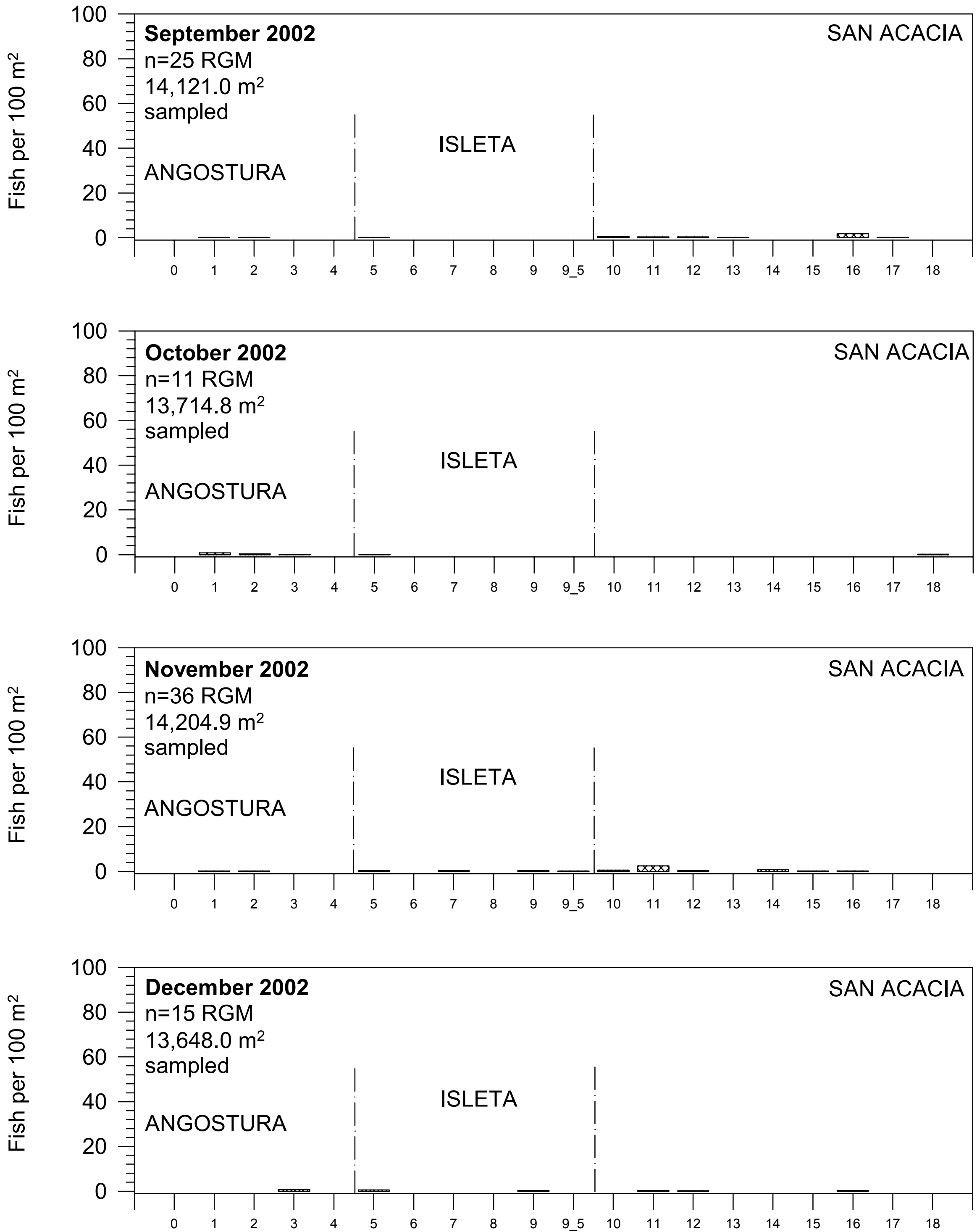

Figure 6. Rio Grande silvery minnow (RGM) catch rates (CPUE) from September-December 2002 for each collection locality in the Middle Rio Grande.

While Rio Grande silvery minnow was present in collections at 16 of 20 sampling localities, only four individuals were collected in the Angostura Reach. Several (n=62) age-0 Rio Grande silvery minnow were collected in the Isleta and San Acacia reaches.

The June 2002 population monitoring trip yielded fewer Rio Grande silvery minnow (n=99) than any of the previous 2002 sampling trips. Young-of-year (= age-0) silvery minnow were collected in the two lower river reaches but comprised only 20% of the cumulative silvery minnow catch. Catch rates of this species were highest at San Acacia Reach sites which, due to river drying, had been reduced to a series of isolated pools. Increased concentrations of fishes in constricted habitats resulted in higher than normal catch rates for fish present, including silvery minnow.

The July 2002 sampling results highlighted the uneven distribution and abundance of Rio Grande silvery minnow in the Middle Rio Grande. The largest site-specific silvery minnow catch rates were recorded in the San Acacia Reach with most (64%) of those individuals being age-0 fish. The number of Rio Grande silvery minnow in collections continued to decline in July 2002 (n=77) and individuals were present at 12 of 20 of the sampling sites.

The August 2002 sampling trip (n=38) produced less than half of the number of Rio Grande silvery minnow taken during July 2002. Individuals of this species were collected in all three sampling reaches but were very rare. The largest collections of Rio Grande silvery minnow were in the San Acacia Reach although <6 individuals were collected at all (n=7) except one of those sites. Very few Rio Grande silvery minnow were taken in either the Angostura (n=3) or Isleta (n=7) reaches. Age-0 Rio Grande silvery minnow comprised about 37% of the total August 2002 catch of this species.

Monitoring of Rio Grande silvery minnow during September 2002 continued to yield few individuals (n=25) indicative of its declining population. This species was present at only nine of 20 sampling sites and was collected from only one locality in the Isleta Reach. The highest catch rates for this species were recorded in the San Acacia Reach although three or fewer individuals were collected at most (5 of 6) collecting localities that produced Rio Grande silvery minnow

The October 2002 sampling effort produced less than half the Rio Grande silvery minnow taken during September 2002, the fewest silvery minnow collected during 2002 (n=11), and one of the lowest catch rates of this species ever recorded. Only one silvery minnow was collected in the San Acacia Reach during October 2002. That individual, an age-0 fish, was collected at the lowest-most sampling site in that reach. Likewise, a single Rio Grande silvery minnow (age-1) was collected in the Isleta Reach in October. The middle three Angostura Reach sampling sites produced the remainder of silvery minnow taken during October 2002 with all of those individuals (n=9) being age-1 fish.

Rio Grande silvery minnow were collected in greater numbers in November 2002 (n=36) than October 2002 but were still some of the lowest catch rates of this species ever recorded. Rio Grande silvery minnow were present in all three reaches and collected at 12 of 20 sampling localities but all except two of those 12 samples contained three or fewer individuals of this species. In November 2002, 72% (n=26) of the cumulative silvery minnow catch was from the San Acacia Reach.

The number of Rio Grande silvery minnow collected in December 2002 was second lowest recorded (n=15) during 2002 and was comprised of both wild and hatchery reared individuals. Silvery minnow collected (n=4) at the Central Avenue Bridge sample site (lower portion of Angostura Reach) were marked with a visible implant elastomer tag and were from the 9 December 2002 release of hatchery-reared specimens by the U. S. Fish and Wildlife Service (Fisheries Resources Office). This was also the largest collection of this species during December 2002. None of the other five sites that yielded silvery minnow during December 2002 resulted in the collection of more than three individuals.

Catch rates of Rio Grande silvery minnow were generally lowest in the Angostura Reach and highest in the San Acacia Reach. The Angostura Reach yielded the fewest silvery minnow (n=129) in 2002 (Figure 7), followed by the Isleta Reach (n=458), and San Acacia Reach (n=1,017). Age-0 individuals comprised a small percentage of the total silvery minnow catch and were most abundant in May and July (Figure 8). Catch rates of Rio Grande silvery minnow, in all reaches, decreased significantly ($p<0.01$) throughout the year (Figure 9) although inter-month variation was moderate.

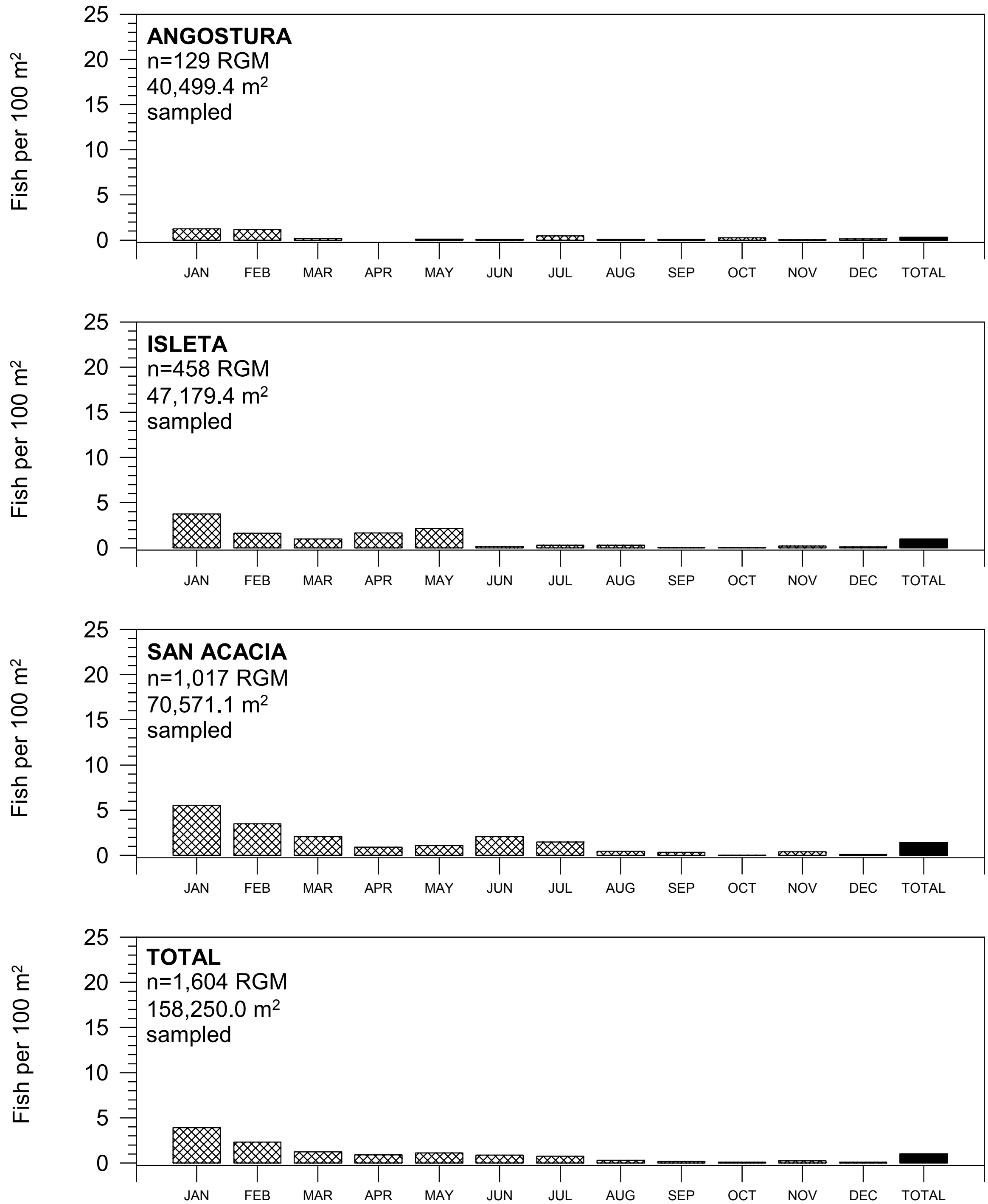

Figure 7. Rio Grande silvery minnow (RGM) catch rates (CPUE) by river reach for each 2002 monthly sample in the Middle Rio Grande.

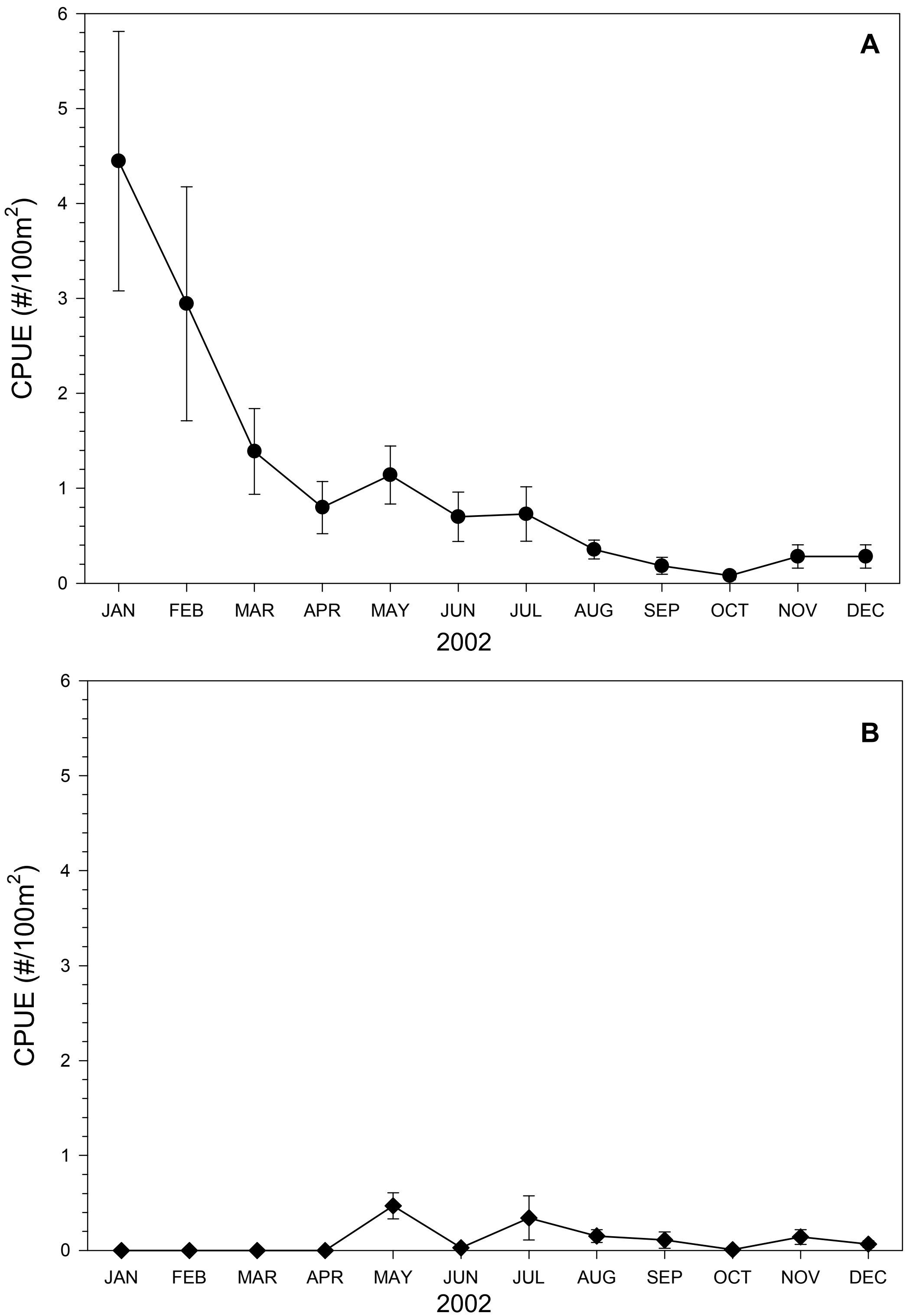

Figure 8. Inter-month fluctuations in catch rates of silvery minnow during 2002 (**A**=all age-classes including age-0 [circle]; **B**=age-0 only [diamond]). Symbols represent mean value for all sites sampled (n=20); bars represent the standard error of mean.

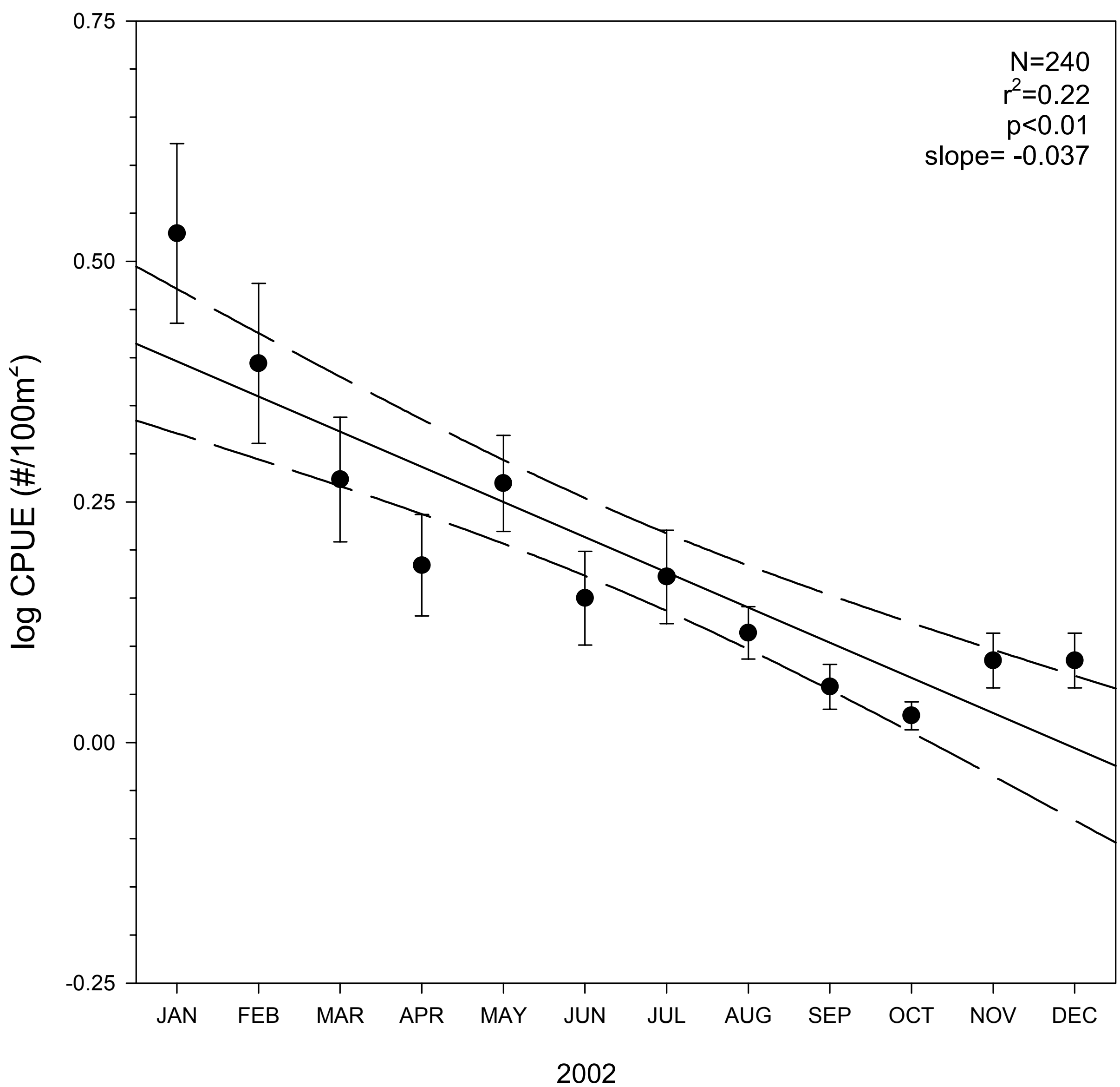

Figure 9. Regression analysis of Rio Grande silvery minnow catch rates (CPUE) during 2002 in all reaches (20 sites), by sampling period (12 months). Graph shows regression line (solid) and 99% confidence intervals (dashed); circles represent mean values and bars represent the standard error of mean.

Analysis of 1993 through 2002 silvery minnow catch rates from October (of each year) revealed significant declines ($p<0.01$) and further highlighted the magnitude of the dwindling population level (Figure 10). The number of Rio Grande silvery minnow taken throughout 2002 was repressed in all reaches but achieved the lowest levels recorded by autumn 2002. Catch rate of Rio Grande silvery minnow reached its nadir during October 2002 when less than one individual was collected per 1,000 m^2 of aquatic habitat sampled. The normal pattern of increased abundance of age-0 silvery minnow following spawning was also absent during 2002. The San Acacia Reach yielded low numbers of Rio Grande silvery minnow throughout the year with the largest catch rates occurring in January and February. This is in sharp contrast to previous years when the abundance of Rio Grande silvery minnow nearly always peaked during spring or summer sampling trips.

A temporal and spatial comparison of Rio Grande silvery minnow collections revealed a significant interaction ($p<0.01$) of mean catch rate with month and locality (Figure 11). The highest catch rates of Rio Grande silvery minnow, in all three river reaches, were generally recorded at or near upstream sampling localities in each respective reach. This spatial distribution of individuals was most pronounced in the Isleta and San Acacia reaches. Downstream collecting localities within a specific river reach generally produced very few Rio Grande silvery minnow and also had a lower level of variation between samples compared with upstream localities.

Fish Community

The 2002 ichthyofaunal community in the Middle Rio Grande between Angostura Diversion Dam and Elephant Butte Reservoir was numerically dominated by cyprinids (Table 2). The native ichthyofauna consisted of eight species (red shiner, Rio Grande chub, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace, river carpsucker, and smallmouth buffalo) that were represented by between one and 73,246 individuals. Rio Grande chub (n=1) was the least abundant native fish with smallmouth buffalo (n=5) being the second least collected native taxon. Red shiner was the most abundant native species collected (n=73,246) followed by fathead minnow (n=23,042), river carpsucker (n=3,798) and flathead chub (n=2,052). The most abundant introduced species were western mosquitofish (n=10,004), white sucker (n=3,499) channel catfish (n=2,733), and common carp (n=843). The 10 remaining nonnative fish species were present at lower abundances (i.e., n<90) than the aforementioned nonnatives.

There were notable seasonal changes in the relative abundance of the ten most abundant fish species during 2002 (Figures 12-14). Catch of all species, with the exception of Rio Grande silvery minnow, increased during spring or summer. The highest catch rate of red shiner was recorded in July although the abundance of this taxon was high throughout the year. Other species whose catch rates peaked in July were flathead chub, longnose dace, and channel catfish. Common carp and fathead minnow were most abundant during the June sampling trip. White sucker, whose abundance peaked during May 2002, spawned earlier in the year (April) than other species. Rio Grande silvery minnow abundance in samples decreased steadily from March through August with the latter months (June-August) being when the highest numbers of individuals are usually collected. Abundance of most species began to decline by September and remained low throughout 2002.

Besides temporal variation in the relative abundances in the fish community, there were also longitudinal differences in the abundance of different fish species (Figure 15). Red shiner, common carp, fathead minnow, and western mosquitofish catch rates were highest in the Isleta Reach and lowest in the Angostura Reach. Catch rate of river carpsucker was highest in the Isleta Reach and lowest in the San Acacia Reach. Longnose dace and white sucker exhibited a similar pattern of higher catch rates in the Angostura Reach compared to the Isleta or San Acacia reaches. Rio Grande silvery minnow was most abundant in the San Acacia Reach, less abundant in the Isleta Reach, and least abundant in the Angostura Reach. Abundance of flathead chub and channel catfish did not differ noticeably between river reaches.

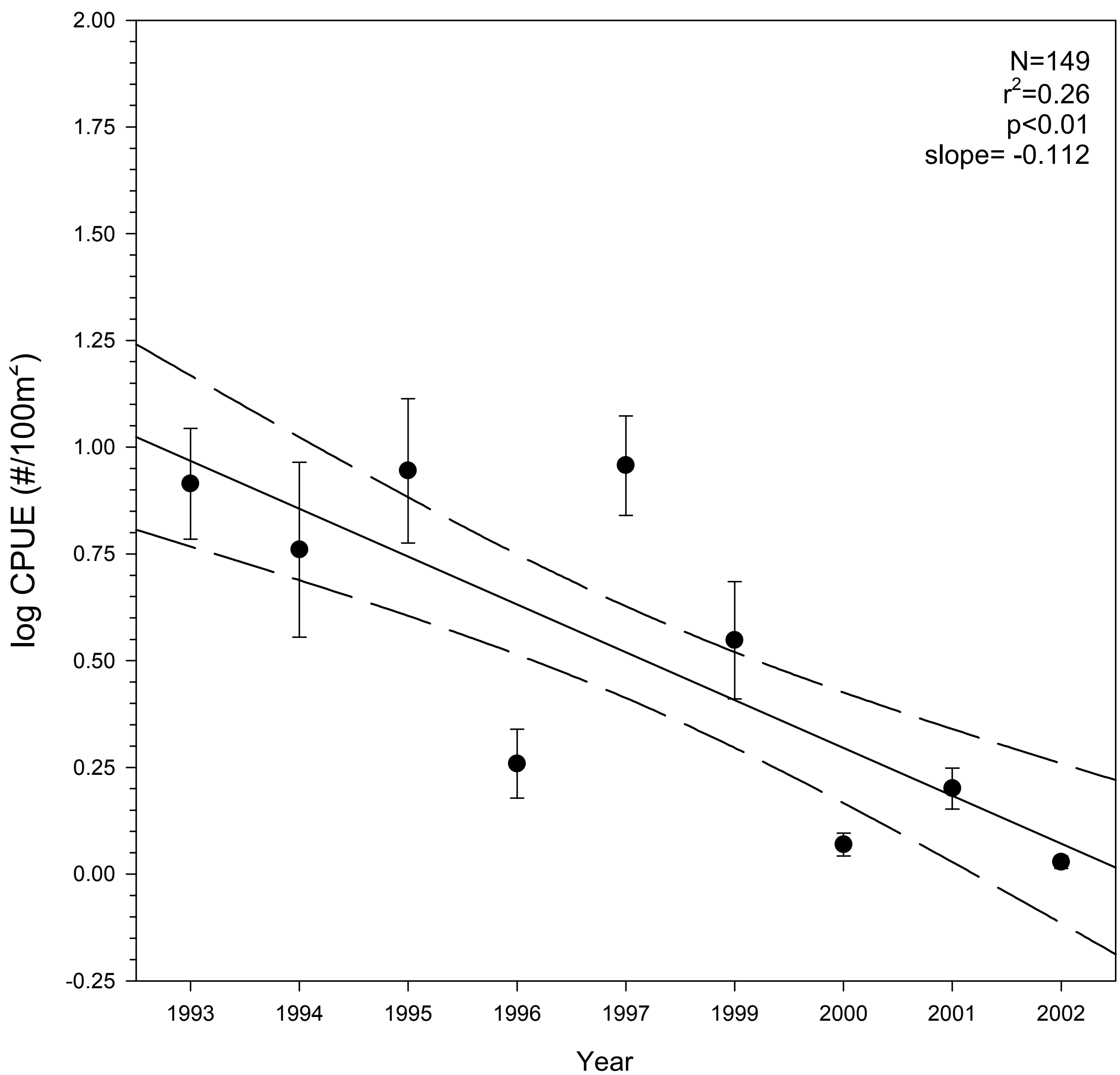

Figure 10. Regression analysis of Rio Grande silvery minnow catch rates (CPUE) during October, in all reaches, by sampling year (1993-2002). Graph shows regression line (solid) and 99% confidence intervals (dashed); circles represent mean values and bars represent the standard error of mean.

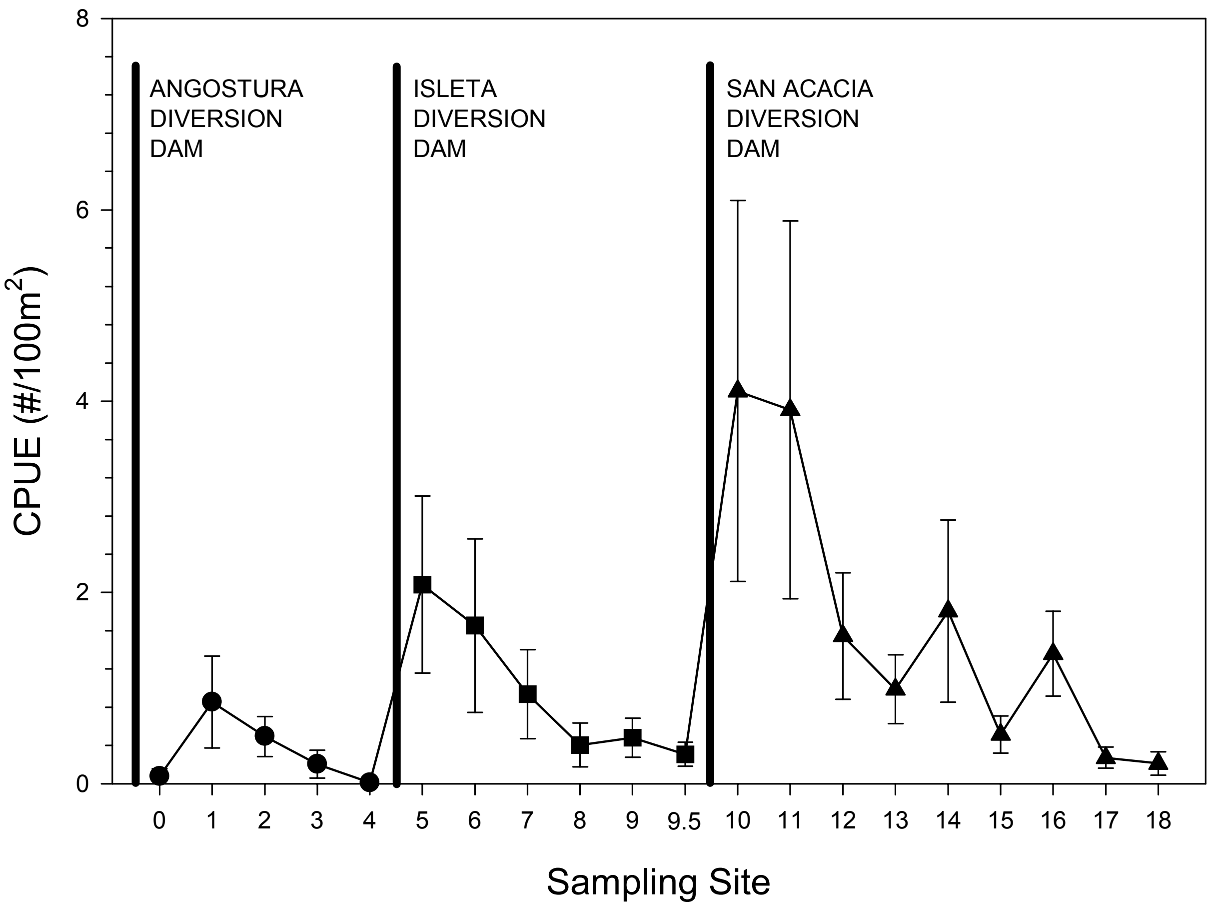

Figure 11. Inter-site comparison of Rio Grande silvery minnow catch rates (CPUE) by sampling locality (20 sites) and river reach (Angostura=circle, Isleta=square, San Acacia=triangle) during 2002. Symbols represent mean values for all sampling months (n=12) and bars represent the standard error of mean.

Table 2. Summary of ichthyofaunal composition and collection data from the Middle Rio Grande for 2002.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	% OF TOTAL
HERRINGS			
gizzard shad	I	60	0.05
CARPS AND MINNOWS			
red shiner *	N	73,246	59.92
common carp *	I	843	0.68
Rio Grande chub	N	1	<0.01
Rio Grande silvery minnow *	N	1,604	1.31
fathead minnow *	N	23,042	18.85
flathead chub *	N	2,052	1.68
longnose dace *	N	1,125	0.92
SUCKERS			
river carpsucker *	N	3,798	3.11
white sucker *	I	3,499	2.86
smallmouth buffalo	N	5	<0.01
BULLHEAD CATFISHES			
black bullhead	I	3	<0.01
yellow bullhead	I	89	0.07
channel catfish *	I	2,733	2.24
LIVEBEARERS			
western mosquitofish *	I	10,004	8.18
TEMPERATE BASSES			
white bass	I	7	<0.01
SUNFISHES			
green sunfish	I	1	<0.01
bluegill	I	9	<0.01
largemouth bass	I	3	<0.01
white crappie	I	75	0.06
PERCHES			
yellow perch	I	8	<0.01
walleye	I	2	<0.01
TOTAL		122,209	100

N = native; I = nonnative
* indicates one of the 10 focal taxa used in all community composition figures

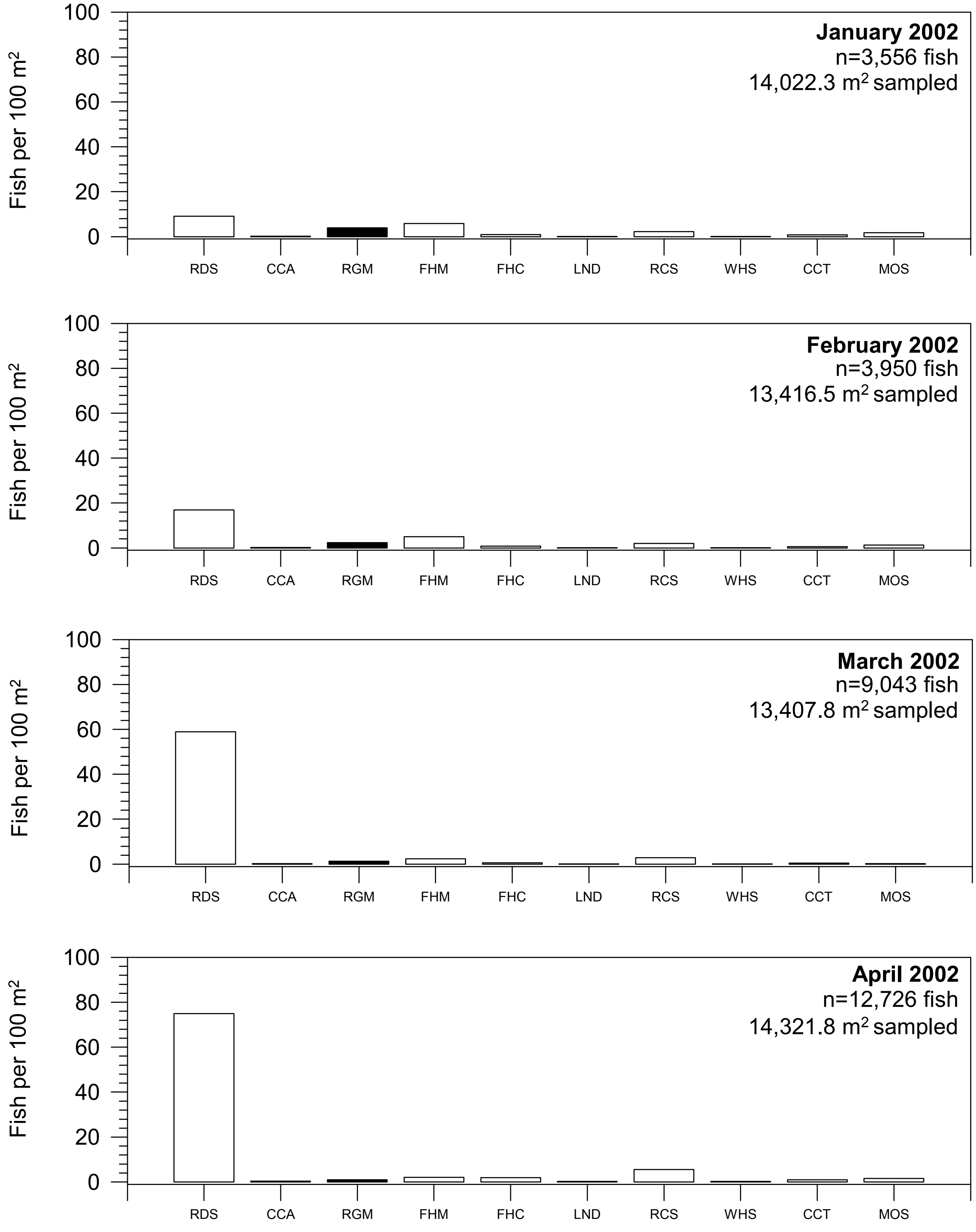

Figure 12. Fish catch rates (CPUE) from January-April 2002 for each focal species (see Table 1 for species codes in 2002) in the Middle Rio Grande. Histogram bar for Rio Grande silvery (RGM) is black to highlight this species.

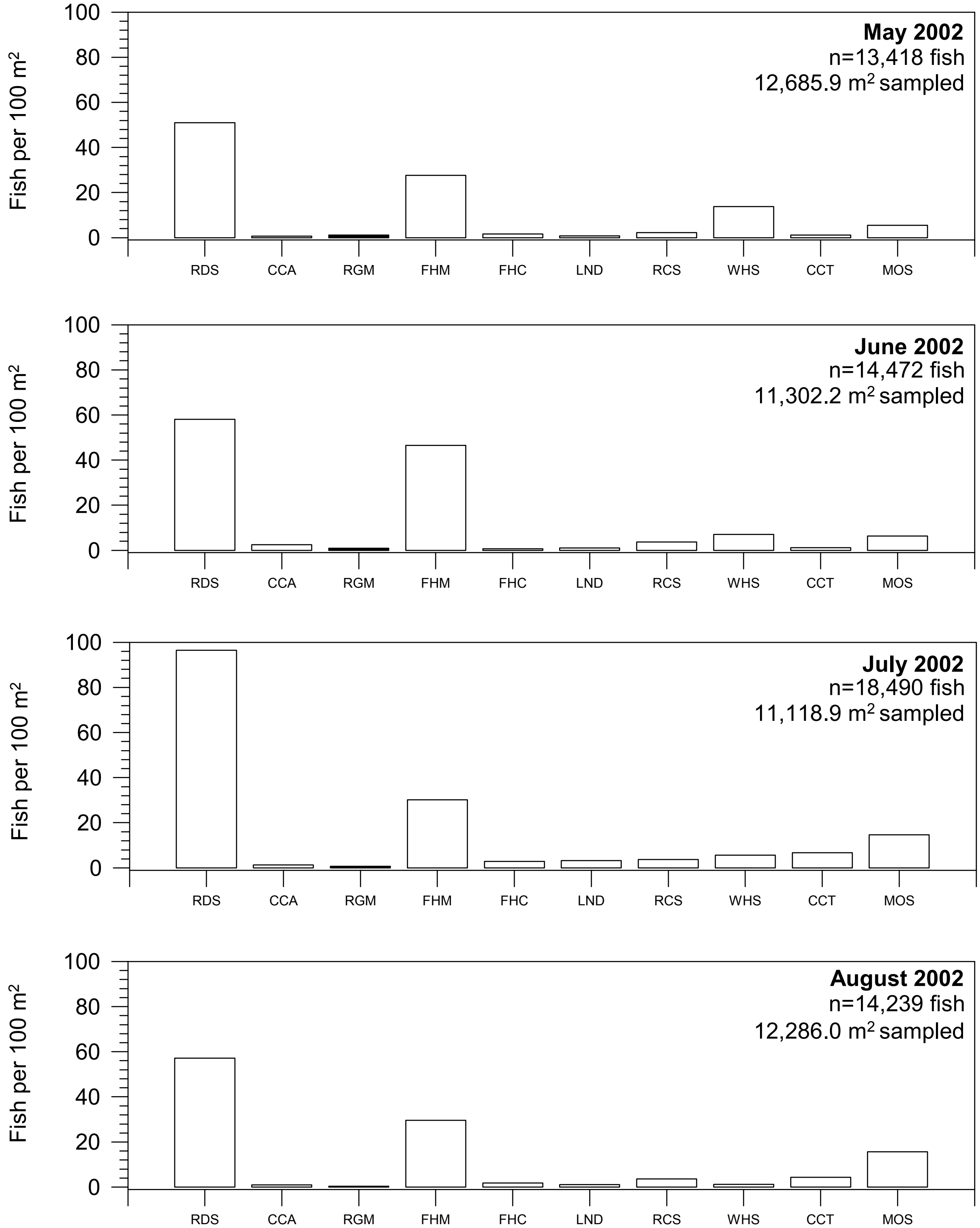

Figure 13. Fish catch rates (CPUE) from May-August 2002 for each focal species (see Table 1 for species codes) in the Middle Rio Grande. Histogram bar for Rio Grande silvery (RGM) is black to highlight this species.

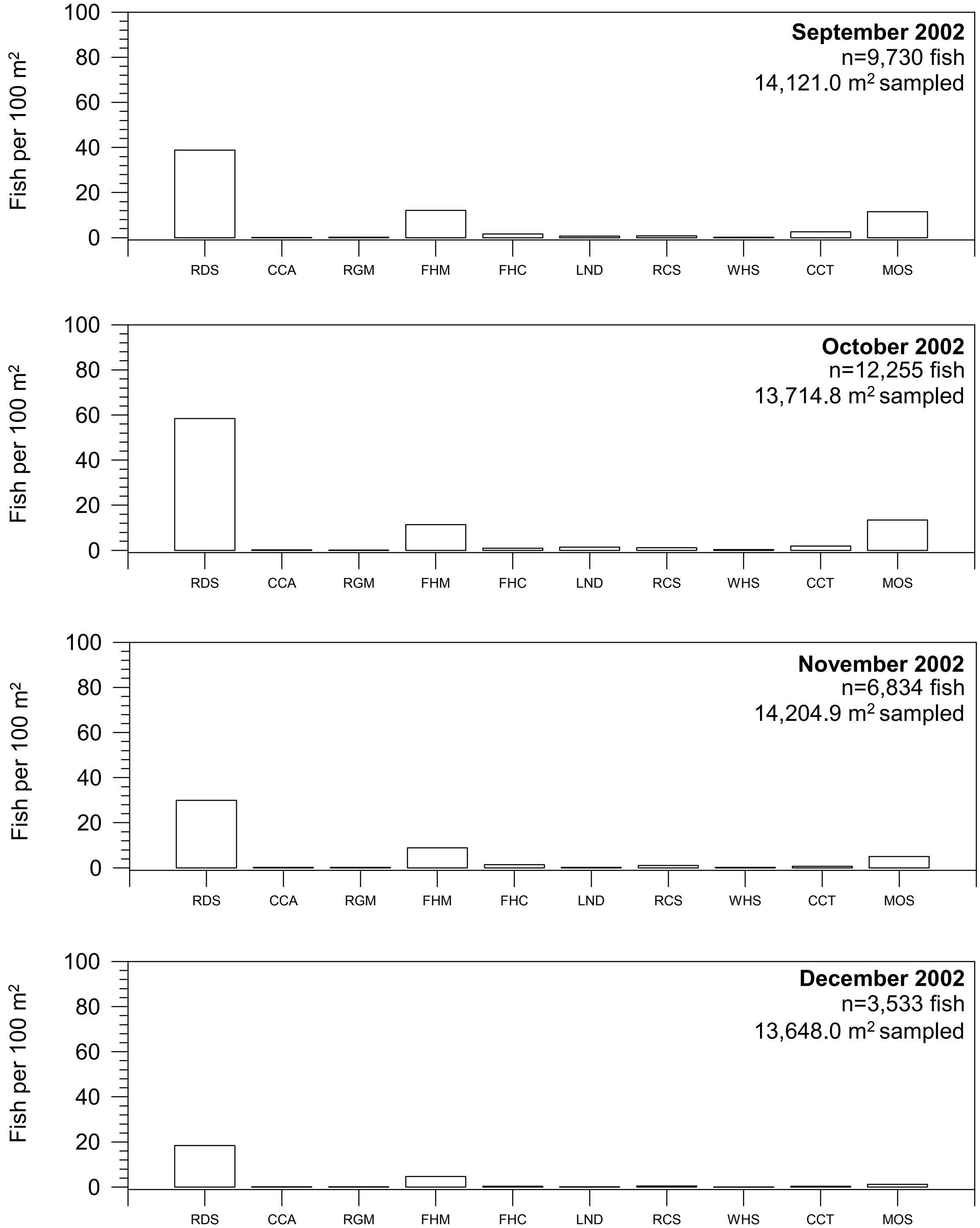

Figure 14. Fish catch rates (CPUE) from September-December 2002 for each focal species (see Table 1 for species codes) in the Middle Rio Grande. Histogram bar for Rio Grande silvery (RGM) is black to highlight this species.

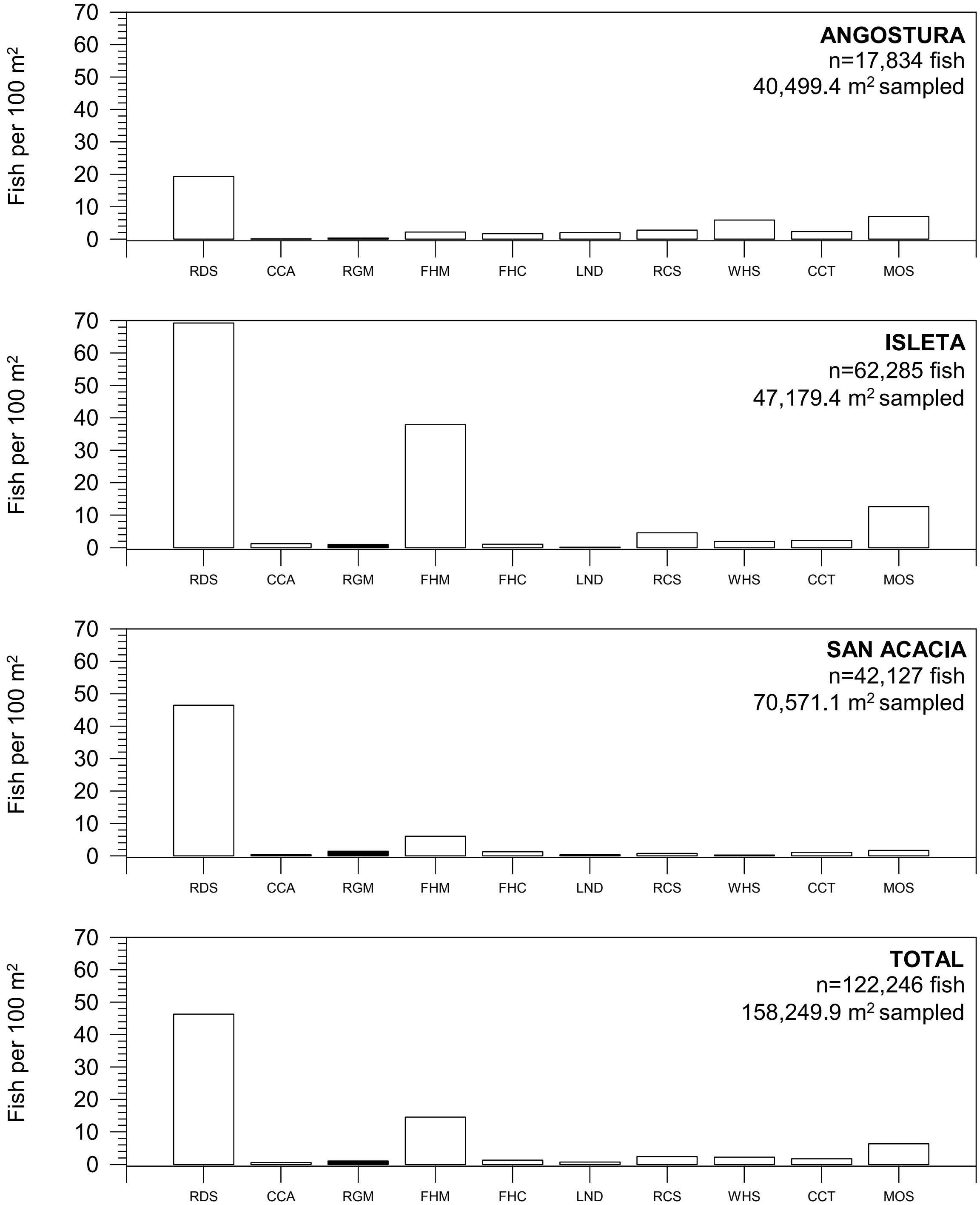

Figure 15. Fish catch rates (CPUE) by river reach for each focal species (see Table 1 for species codes) in the Middle Rio Grande during 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

Relative abundance of all fish species in 2002 fluctuated between sampling periods for each of the river reaches (Figure 16). An increase, of varying magnitudes, in the relative abundance of fish occupying the three river reaches was discerned in March-August samples but declines were generally apparent by September. Increases in fish catch rate occurred in July in the San Acacia Reach and in August in the Isleta Reach. Isleta Reach fish catch rates were moderately high from February through October primarily because of the large number of red shiner and western mosquitofish collected there. Overall catch rates for all reaches combined peaked in July.

Catch rates of individual taxa in the study reaches varied extensively by sampling period (Figures 17-19). Fish catch rates in the Angostura Reach were low for most focal species except red shiner, white sucker, and western mosquitofish. Rio Grande silvery minnow catch rates, low throughout 2002, were collected from at least one Angostura Reach site during almost every monthly sampling trip. Red shiner was most common in samples taken in April and October. White sucker abundance peaked in May and June following spawning by this species. Western mosquitofish was most abundant in August-October Angostura Reach samples. Relative abundance of most other focal species in the Angostura Reach peaked during July and declined to pre-spawning levels by November.

Fish catch rates in the Isleta Reach, like those in the Angostura Reach, also peaked from May through August. Red shiner, fathead minnow, and white sucker were quite abundant in the May sampling effort. Fathead minnow was extremely abundant throughout the summer especially in June and August samples. Rio Grande silvery minnow abundance in the Isleta Reach was low throughout the year but a small number of individuals was collected in this reach during each sampling month. Red shiner abundance was relatively high throughout 2002 but the largest collections of this species were taken in April and August. Channel catfish were most abundant in July and August samples.

The 2002 relative abundance of red shiner in the San Acacia Reach remained high from March through July but declined rapidly by August and remained moderately low throughout the rest of the year. Rio Grande silvery minnow catch rates in the San Acacia Reach were somewhat higher than in the Angostura or Isleta reaches throughout the year. There was a slight increase in Rio Grande silvery minnow abundance during June following flows that triggered spawning in May 2002. However, number of Rio Grande silvery minnow taken was very low by autumn of 2002. The abundance of other fish species (common carp, fathead minnow, longnose dace, river carpsucker, and western mosquitofish) peaked in June and July 2002. The only species whose abundance increased in August 2002 in the San Acacia Reach was channel catfish.

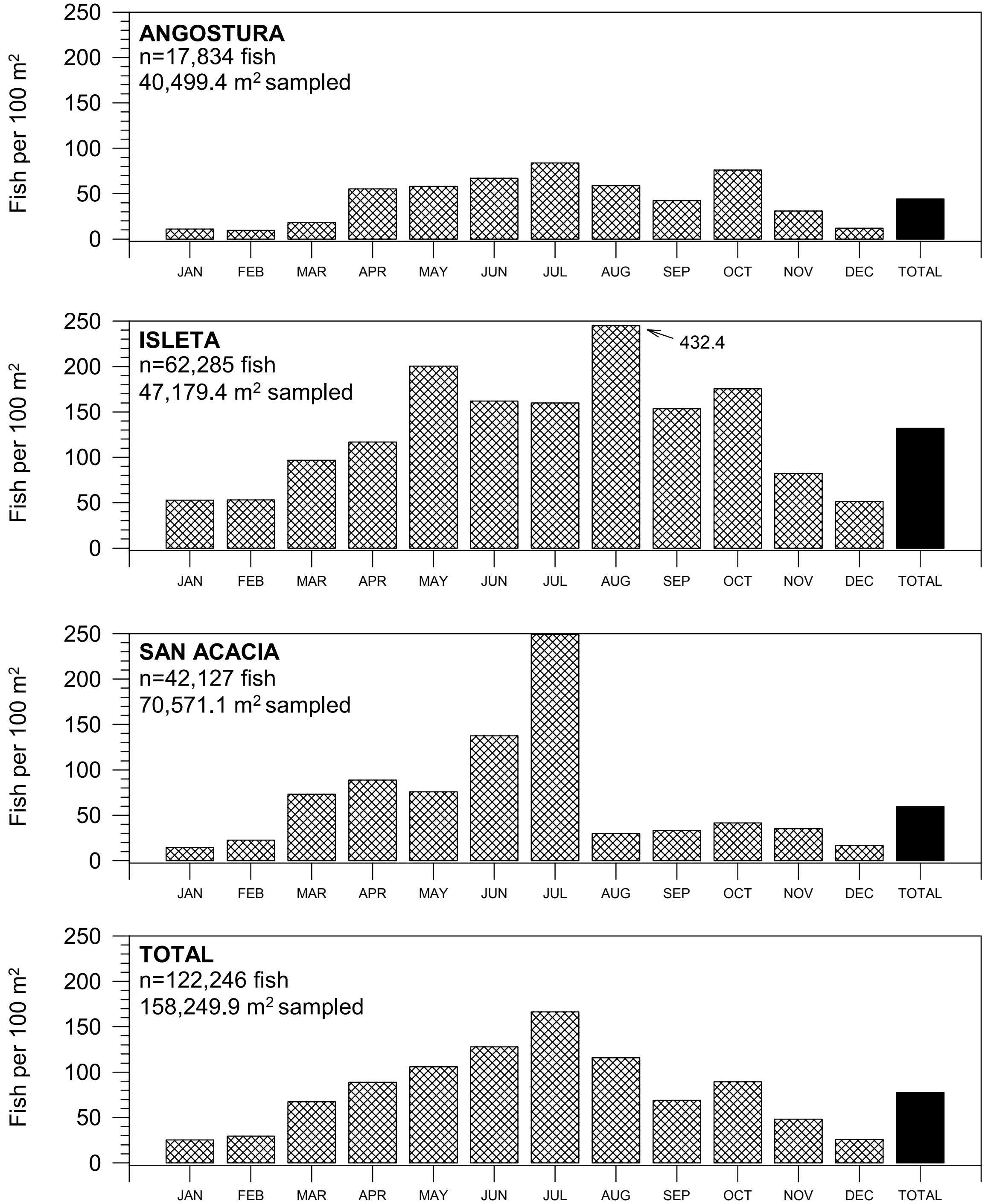

Figure 16. Fish catch rates (CPUE) by river reach for each sampling period in the Middle Rio Grande during 2002.

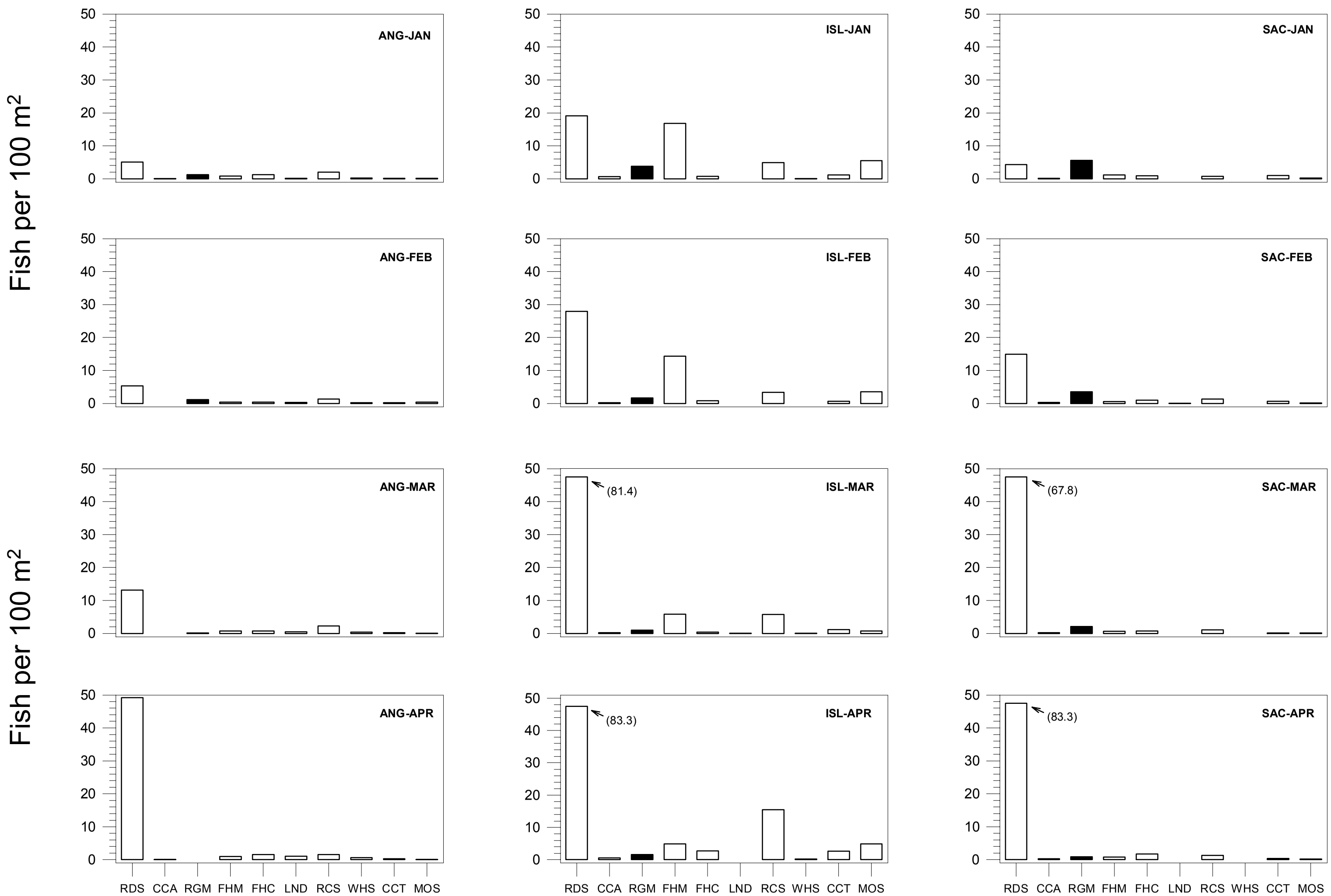

Figure 17. Fish catch rates (CPUE) by river reach from January-April 2002 for each focal species (see Table 1 for species codes) in the Middle Rio Grande (ANG=Angostura, ISL=Isleta, and SAC=San Acacia). Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

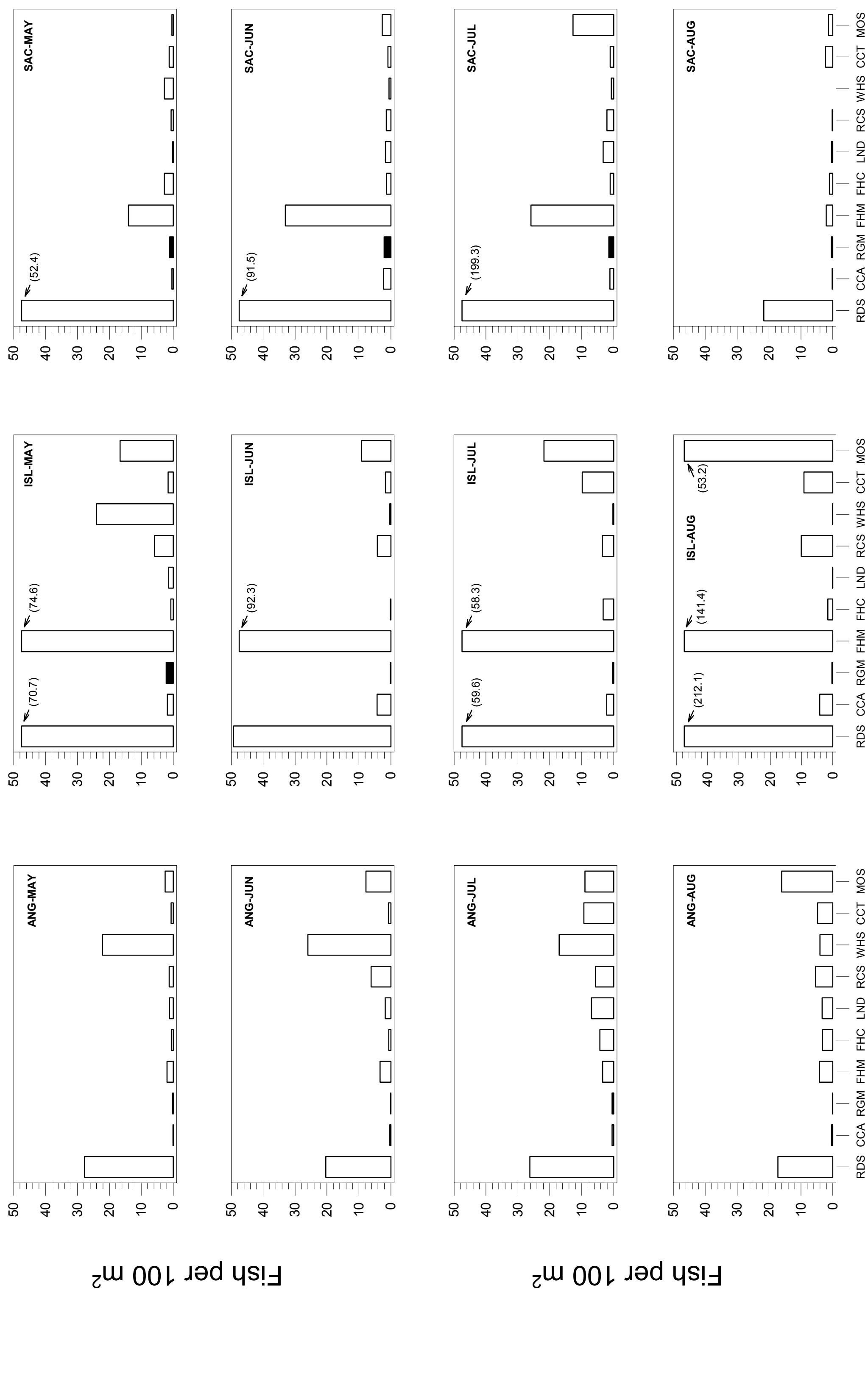

Figure 18. Fish catch rates (CPUE) by river reach from May-August 2002 for each focal species (see Table 1 for species codes) in the Middle Rio Grande (ANG=Angostura, ISL=Isleta, and SAC=San Acacia). Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

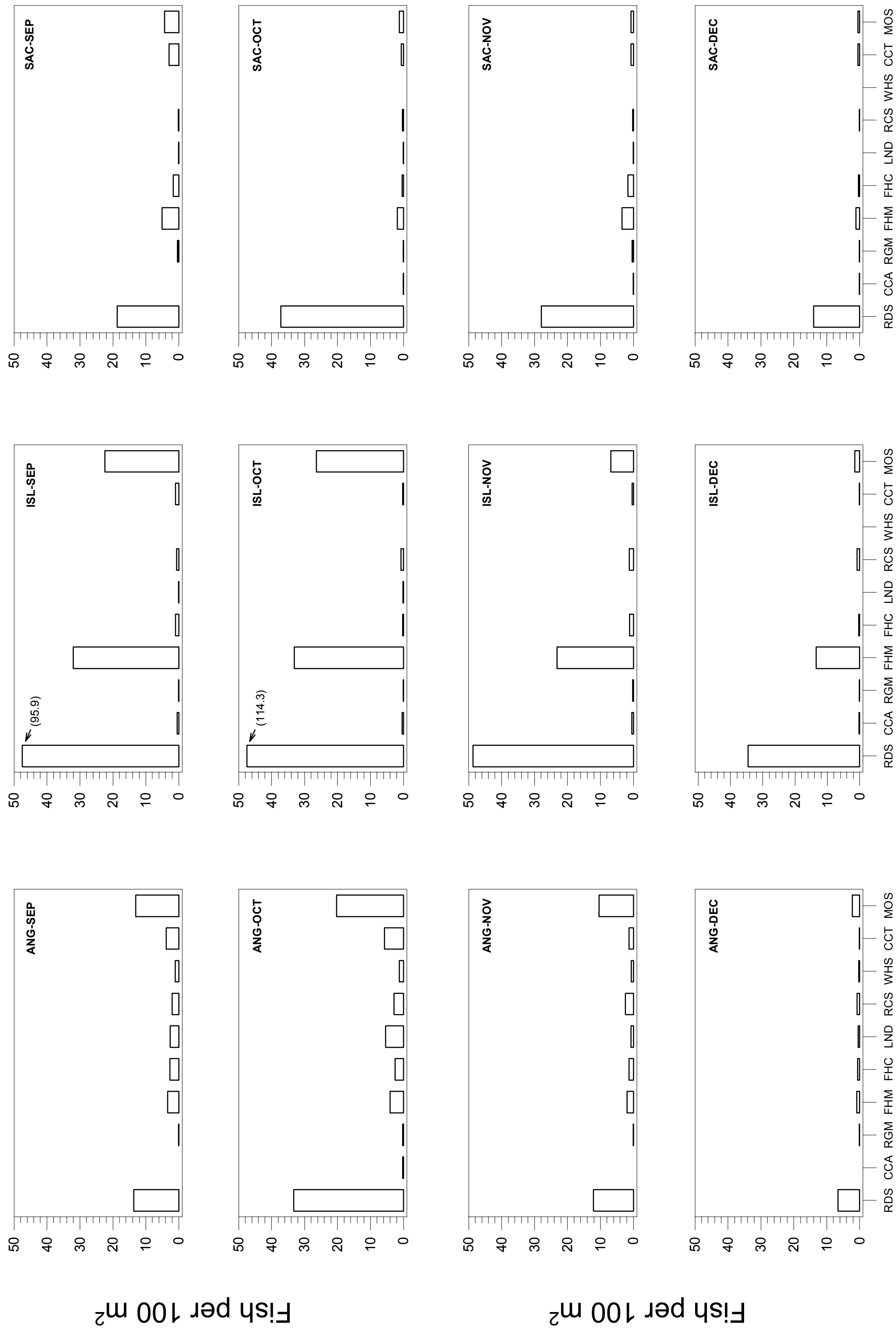

Figure 19. Fish catch rates (CPUE) by river reach from September-December 2002 for each focal species (see Table 1 for species codes) in the Middle Rio Grande (ANG=Angostura, ISL=Isleta, and SAC=San Acacia). Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

DISCUSSION

Low winter precipitation in combination with river diversions resulted in a steady and extended period of low flow in the Middle Rio Grande throughout 2002. The lack of snowpack at high elevations in the Rio Grande Basin produced a spring runoff pattern that resembled hydrologic conditions more commonly observed during summer low flow periods. Occasional periods of river drying occurred in the Middle Rio Grande from late spring through early autumn. The areas that most frequently dried during 2002 were sections of the river near Bosque del Apache National Wildlife Refuge and several km upstream of the U. S. Highway 380 Bridge crossing near San Antonio, New Mexico. During periods of low flow, the lower section of the San Acacia Reach of the Rio Grande was almost entirely supplemented by water pumped from the Low Flow Conveyance Channel into the Rio Grande. This strategy prevented river drying but flow in this section of the Rio Grande remained very low and static throughout much of the summer.

The annual reproductive effort of Rio Grande silvery minnow normally occurs during spring and is initiated, in part, by a large-scale increase in stream discharge associated with high mountain snowmelt. The reproductive strategy of this species results in the production of relatively large numbers of eggs that are released into the water column and dispersed downstream. Spring runoff, combined with increasing water temperatures, was likely the historical source of this reproductive stimulus. During years of sufficient snowpack, flow in the Middle Rio Grande peaked in late spring and resulted in several months of sustained flooded habitats. However, dams and reservoirs now moderate the magnitude, amplitude, and duration of spring discharge. Water diverted from the river for agricultural purposes can substantially reduce the total volume of water that would normally have flowed in the Rio Grande. This problem is further compounded in drought years when proportionally larger volumes of water are removed from the Rio Grande in early spring often drying the sections of the river or absorbing peak flows that stimulate silvery minnow spawning.

During the 2002 drought, a relatively large amount of water was released from Cochiti Dam during 13-16 May 2002 with the intent of stimulating a spawning response by Rio Grande silvery minnow. Over 99% of Rio Grande silvery minnow eggs collected during May 2002 were a direct result of this artificial flow spike (Platania and Dudley, 2003). There was a low spawning response by this species to increases in flow that occurred subsequent to the May flow spike. It appears that the spawning triggered by the artificial spike was strong enough to stimulate reproduction by a considerable portion of the Rio Grande silvery minnow population.

Although a relatively large number of Rio Grande silvery minnow eggs were collected during 2002 near the southern terminus of this species range, this production of propagules ultimately failed to resulted in the recruitment of very many individuals into the 2002 year-class nor did it improve the conservation status of the species in the wild. Catch rates of this fish in all three river reaches declined steadily throughout 2002 and resulted in some of the lowest population monitoring numbers of Rio Grande silvery minnow ever recorded in the Middle Rio Grande. A lack of young-of-year individuals was prominent during summer (June, July, August) population monitoring efforts. While the abundance of Rio Grande silvery minnow normally increases dramatically following spring spawning efforts, catch rates of Rio Grande silvery minnow during 2002 actually decreased through this period and very few young-of-year silvery minnow were collected from June-August 2002.

The timing of the May 2002 flow spike was similar to a flow increase that would normally be expected at the onset of the spring runoff period. During years of normal Rio Grande Basin snowpack, runoff would begin in May and last for an extended period (weeks) in contrast to the artificial spike which lasted for about five days. Flow in the river had returned to extremely low levels within a week of the brief period of elevated discharge induced by the artificial spike. The spawned eggs and subsequent larvae that were produced as a result of this flow event were subjected to biotic and physical conditions that may have precluded their successful growth and survivorship.

Excessively elevated water temperatures in the Rio Grande, caused by warm ambient conditions and low flows, may have reduced the hatching success of newly spawned eggs and survival of larvae (Platania and Dudley, 2003). In addition to high water temperatures and possibly poor water quality, the likelihood of intra- and inter-specific interactions would be expected to increase during low flows as available aquatic habitat decreases. It is likely that recruitment success of Rio Grande silvery minnow was reduced by interactions with other fish during this period.

The 2002 population levels of Rio Grande silvery minnow, as determined from this population monitoring effort, were markedly lower than those recorded in 2001 throughout the Middle Rio Grande. While February and April 2001 catch rates of Rio Grande silvery minnow were similar to those of February and April 2002, the June catch rate of age-0 individuals were notably lower in 2002 than June 2001. This decrease in abundance of age-0 Rio Grande silvery minnow suggest that conditions were less suitable for recruitment in 2002 compared with 2001.

There were numerous, sometimes substantial, differences in the timing, magnitude, and duration of spring flows and river conditions in the Middle Rio Grande between 2001 and 2002. Spring flows never exceeded 400 cfs during May or June 2002 (as recorded at the San Marcial gauge). The artificial flow spike in mid-May 2002 resulted in a several day period of elevated flows at upstream and downstream sampling localities but flows quickly returned to pre-spike levels following this temporary water release (Figure 20). The highest recorded mean daily flow at the San Marcial gauge during the 2002 event was about 400 cfs but river flows had dropped to <100 cfs within three days of the peak. Within one week of this Rio Grande silvery minnow spawn inducing flow event, mean daily discharge in the Rio Grande at the San Marcial was about 50 cfs and declined to about 25 cfs the following week. A similar pattern was noted at upstream gauging stations during spring 2002 except that flow peaks were higher and absolute discharge fluctuations were greater.

In contrast, spring flows during 2001 followed a much different pattern than that observed in 2002. While the beginning of the spring runoff period in 2001 and 2002 were very similar (i.e., rise in river flows that were >100 cfs/day over several days), the elevated flows in 2001 persisted for a much longer period than during 2002. Mean daily discharge at San Marcial during mid-May 2001 increased to over 2,000 cfs and then remained over 1,000 for several weeks following this gradual peak in river flows. It was almost one month before 2001 flow at San Marcial had receded to <100 cfs following the peak spring runoff event. Similar sustained high flows that persisted for more than one month were also observed at upstream sites in the Rio Grande during 2001.

That spring flows following Rio Grande silvery minnow spawning in 2001, compared with 2002, were dramatically different seem a primary reason for the differences in the abundance of Rio Grande silvery minnow between these two years. Although the collection of large numbers of eggs in 2002 suggests a relatively strong spawning effort by Rio Grande silvery minnow (Platania and Dudley, 2003), the survival of these propagules is determined by abiotic and biotic factors of the riverine environment. Flow conditions following the May 2002 flow spike may not have been conducive for survival of young Rio Grande silvery minnow. In addition to multiple post-May river drying events that resulted in losses of all age-classes of Rio Grande silvery minnow, periods of extended low flow probably decreased the likelihood of successful recruitment of young-of-year individuals.

In addition to losses of Rio Grande silvery minnow caused by river drying and low flows, an ongoing factor in the decline of this species is the fragmentation of its range and longitudinal displacement of its propagules (drifting eggs and larvae) below instream barriers (i.e., Angostura, Isleta, and San Acacia diversion dams). These channel-wide structures do not preclude downstream passage of fish or their reproductive products but do prevent fish movement upstream of the diversion dam structures. Considerable upstream movement of this species (>25 km) was recently verified in marked hatchery reared individuals (Platania, et al., 2003) providing further validation of the negative impact of these structures have on Rio Grande silvery minnow populations.

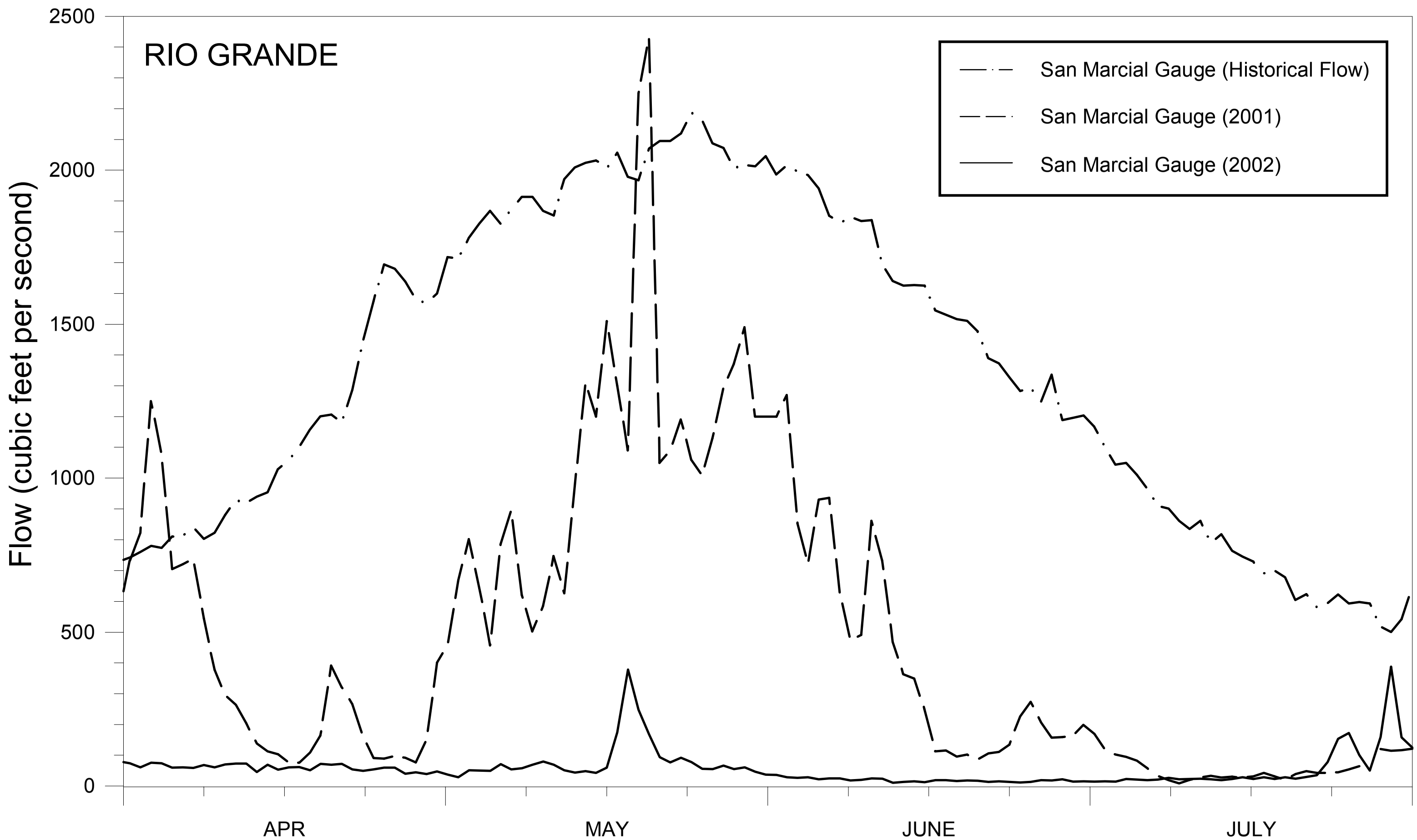

Figure 20. Hydrograph of the Rio Grande, NM at San Marcial based on historical mean daily flow data (52 yr.) and for mean daily flow in 2001 and 2002. (Note: Hydrological data are from the U. S. Geological Survey and are provisional).

Given the reproductive ecology of this species, reach lengths, and diversion dam placement, the sequential decline and loss of this species from upstream to downstream was predicted (Platania and Altenbach, 1998). Fragmentation of this species range in the Middle Rio Grande due to Angostura, Isleta, and San Acacia diversion dams has been identified as an issue of paramount importance that requires resolution for recovery of Rio Grande silvery minnow (U. S. Fish and Wildlife Service, 1999).

The Isleta Reach is an intermediate reach, not only in geographic position but also in regards to flow. This reach does not maintain the volume or consistency of discharge as the Angostura Reach but, because of the numerous points of irrigation returns, has an increased likelihood of maintaining some continuous flow compared to the San Acacia Reach. Issues regarding range fragmentation and downstream transport of silvery minnow propagules in the Angostura Reach are equally as important in the Isleta Reach. Declines in the Rio Grande silvery minnow population in the Angostura Reach will result in fewer eggs and larvae being transported into the Isleta Reach and thereby negatively affect population levels in the latter reach. Likewise, fewer individuals in the Isleta and Angostura reaches will translate to a lower Rio Grande silvery minnow population level in the San Acacia Reach.

The barrier to upstream movement imposed by San Acacia Diversion Dam in combination with the downstream transport of silvery minnow eggs and larvae (especially those produced in the San Acacia Reach) into Elephant Butte Reservoir continue to adversely impact the San Acacia Reach population of this species. The effects of these problems are synergistic and become especially critical during periods when population levels of this species is extremely low, as seen in 2002. Efforts to maintain increased and variable flow throughout the Middle Rio Grande in 2003 is essential as substantial losses of Rio Grande silvery minnow from the San Acacia Reach could potentially lead to the extirpation of this species from the wild.

The cumulative effects of several consecutive years of river drying, downstream displacement, and habitat degradation continue to be manifested in the decline of Rio Grande silvery minnow. The marked and alarming declines in abundance of Rio Grande silvery minnow recorded in 2002 during this population monitoring study provide the strongest evidence that the problems that led to the precipitous decline of this species have not been remedied. A renewed focus on issues that directly affect the immediate survival of this species in the wild is essential. Removal of instream barriers that prevent Rio Grande silvery minnow from repopulating upstream reaches, the need to maintain increased and variable flow throughout downstream reaches, and restoration and reconnection of the historical floodplain are paramount issues that need to be resolved to assure the continued persistence of this species.

ACKNOWLEDGMENTS

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Appendix A.

2002 Collection localities and monthly fish catch rates by collection locality for each focal species

Table A-1. Collection localities for 2002 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality
	ANGOSTURA REACH SITES
0	New Mexico, Sandoval County, Rio Grande, directly below Angostura Diversion Dam, Angostura. River Mile 209.7 SAN FELIPE PUEBLO QUADRANGLE UTM Easting: 363811 UTM Northing: 3916006 Zone: 13
1	New Mexico, Sandoval County, Rio Grande, at NM State Highway 44 bridge crossing, Bernalillo. River Mile 203.8 BERNALILLO QUADRANGLE UTM Easting: 358543 UTM Northing: 3909722 Zone: 13
2	New Mexico, Sandoval County, Rio Grande, ca. 4.0 miles downstream of NM State Highway 44 bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho. River Mile 200.0 BERNALILLO QUADRANGLE UTM Easting: 354772 UTM Northing: 3905355 Zone: 13
3	New Mexico, Bernalillo County, Rio Grande, at Central Avenue bridge crossing (US Highway 66), Albuquerque. River Mile 183.4 ALBUQUERQUE WEST QUADRANGLE UTM Easting: 346840 UTM Northing: 3884094 Zone: 13
4	New Mexico, Bernalillo County, Rio Grande, at Rio Bravo Boulevard bridge crossing, (NM State Highway 500), Albuquerque. River Mile 178.3 ALBUQUERQUE WEST QUADRANGLE UTM Easting: 347554 UTM Northing: 3877163 Zone: 13
	ISLETA REACH SITES
5	New Mexico, Valencia County, Rio Grande at Los Lunas bridge crossing (NM State Highway 49), Los Lunas. River Mile 161.4 LOS LUNAS QUADRANGLE UTM Easting: 342898 UTM Northing: 3852531 Zone: 13
6	New Mexico, Valencia County, Rio Grande, ca. 1.0 miles upstream of NM State Highway 309/6 bridge crossing, Belen. River Mile 151.5 TOME QUADRANGLE UTM Easting: 339972 UTM Northing: 3837061 Zone: 13

Table A-1. Collection localities for 2002 population monitoring of Rio Grande silvery minnow (continued).

Site #	Site Locality
	ISLETA REACH SITES (continued)
7	New Mexico, Valencia County, Rio Grande, ca. 2.2 miles upstream of NM State Highway 346 bridge crossing, Jarales. River Mile 143.2 VEGUITA QUADRANGLE UTM Easting: 338136 UTM Northing: 3827329 Zone: 13
8	New Mexico, Socorro County, Rio Grande, at US Highway 60 bridge crossing, Bernardo. River Mile 130.6 ABEYTAS QUADRANGLE UTM Easting: 334604 UTM Northing: 3809726 Zone: 13
9	New Mexico, Socorro County, Rio Grande, ca. 3.5 miles downstream of US Highway 60 bridge crossing, Bernardo. River Mile 127.0 ABEYTAS QUADRANGLE UTM Easting: 331094 UTM Northing: 3805229 Zone: 13
9.5	New Mexico, Socorro County, Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia River Mile 116.8 LA JOYA QUADRANGLE UTM Easting: 327902 UTM Northing: 3792603 Zone: 13
	SAN ACACIA REACH SITES
10	New Mexico, Socorro County, Rio Grande, directly below San Acacia Diversion Dam, San Acacia. River Mile 116.2 SAN ACACIA QUADRANGLE UTM Easting: 326162 UTM Northing: 3791977 Zone: 13
11	New Mexico, Socorro County, Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. River Mile 114.6 LEMITAR QUADRANGLE UTM Easting: 325263 UTM Northing: 3790442 Zone: 13
12	New Mexico, Socorro County, Rio Grande, east of Socorro, 0.5 miles upstream of the Socorro Low Flow Conveyance Channel bridge; east and upstream of Socorro Wastewater Treatment Plant, Socorro. River Mile 99.5 LOMA DE LAS CANAS QUADRANGLE UTM Easting: 327097 UTM Northing: 3771043 Zone: 13

Table A-1. Collection localities for 2002 population monitoring of Rio Grande silvery minnow (continued).

Site #	Site Locality
	SAN ACACIA REACH SITES (continued)
13	New Mexico, Socorro County, Rio Grande, ca. 4.0 miles upstream of US Highway 380 bridge crossing. River Mile 91.7 SAN ANTONIO QUADRANGLE UTM Easting: 328140 UTM Northing: 3761283 Zone: 13
14	New Mexico, Socorro County, Rio Grande, at US Highway 380 bridge crossing, San Antonio. River Mile 87.1 SAN ANTONIO QUADRANGLE UTM Easting: 328914 UTM Northing: 3754471 Zone: 13
15	New Mexico, Socorro County, Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. River Mile 79.1 SAN ANTONIO, SE QUADRANGLE UTM Easting: 327055 UTM Northing: 3740839 Zone: 13
16	New Mexico, Socorro County, Rio Grande, at San Marcial Railroad bridge crossing, San Marcial. River Mile 68.6 SAN MARCIAL QUADRANGLE UTM Easting: 315284 UTM Northing: 3728347 Zone: 13
17	New Mexico, Socorro County, Rio Grande, at its former confluence with the Low Flow Conveyance Channel; 16 miles downstream of the southern end of the Bosque del Apache National Wildlife Refuge; ca. 8 miles downstream of San Marcial Railroad bridge crossing. River Mile 60.5 PARAJE WELL QUADRANGLE UTM Easting: 309487 UTM Northing: 3718178 Zone: 13
18	New Mexico, Socorro County, Rio Grande, ca. 19 miles downstream of the southern end of the Bosque del Apache National Wildlife Refuge. River Mile 57.7 PARAJE WELL QUADRANGLE UTM Easting: 307380 UTM Northing: 3714740 Zone: 13

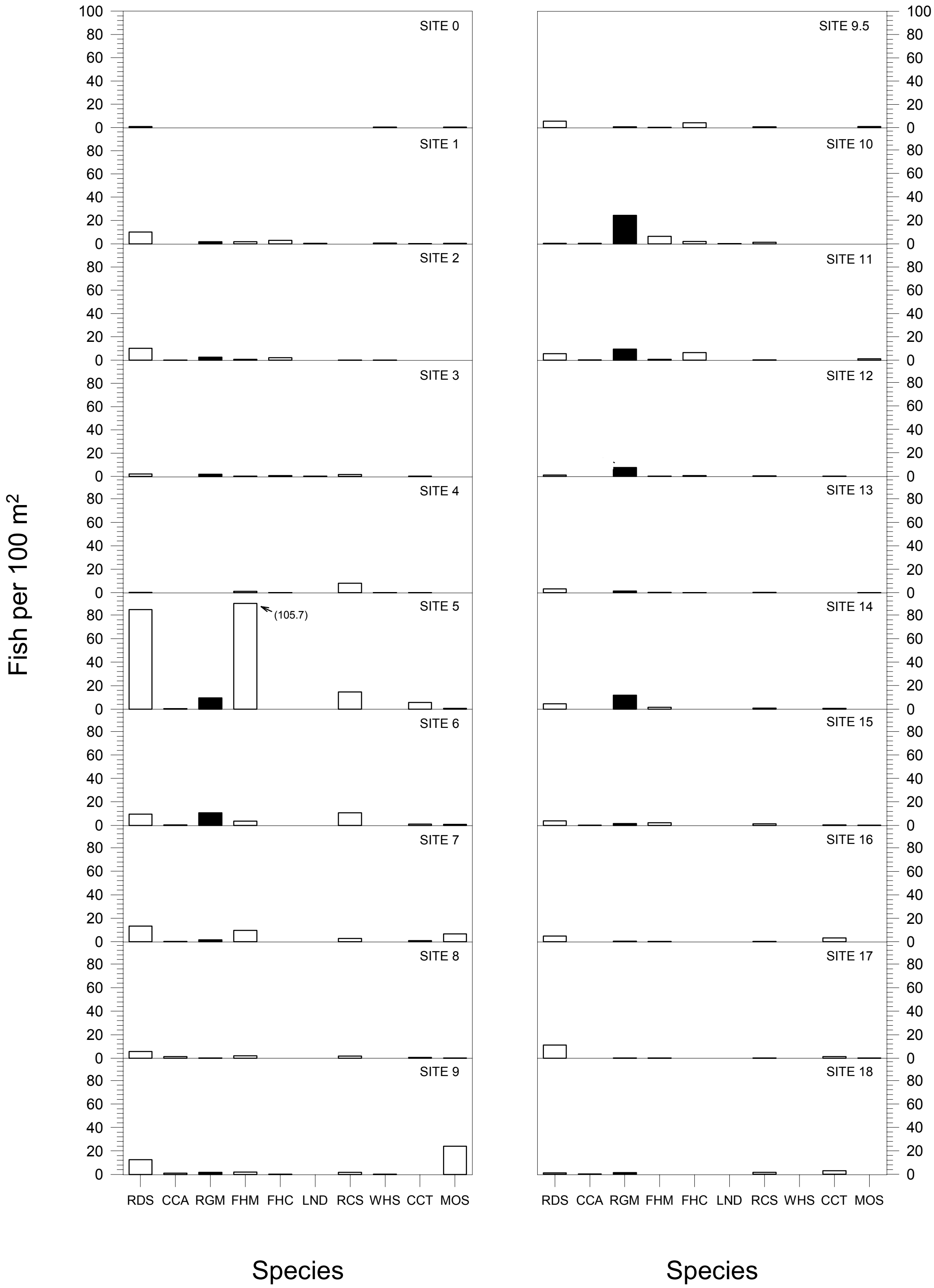

Figure A-1. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for January 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

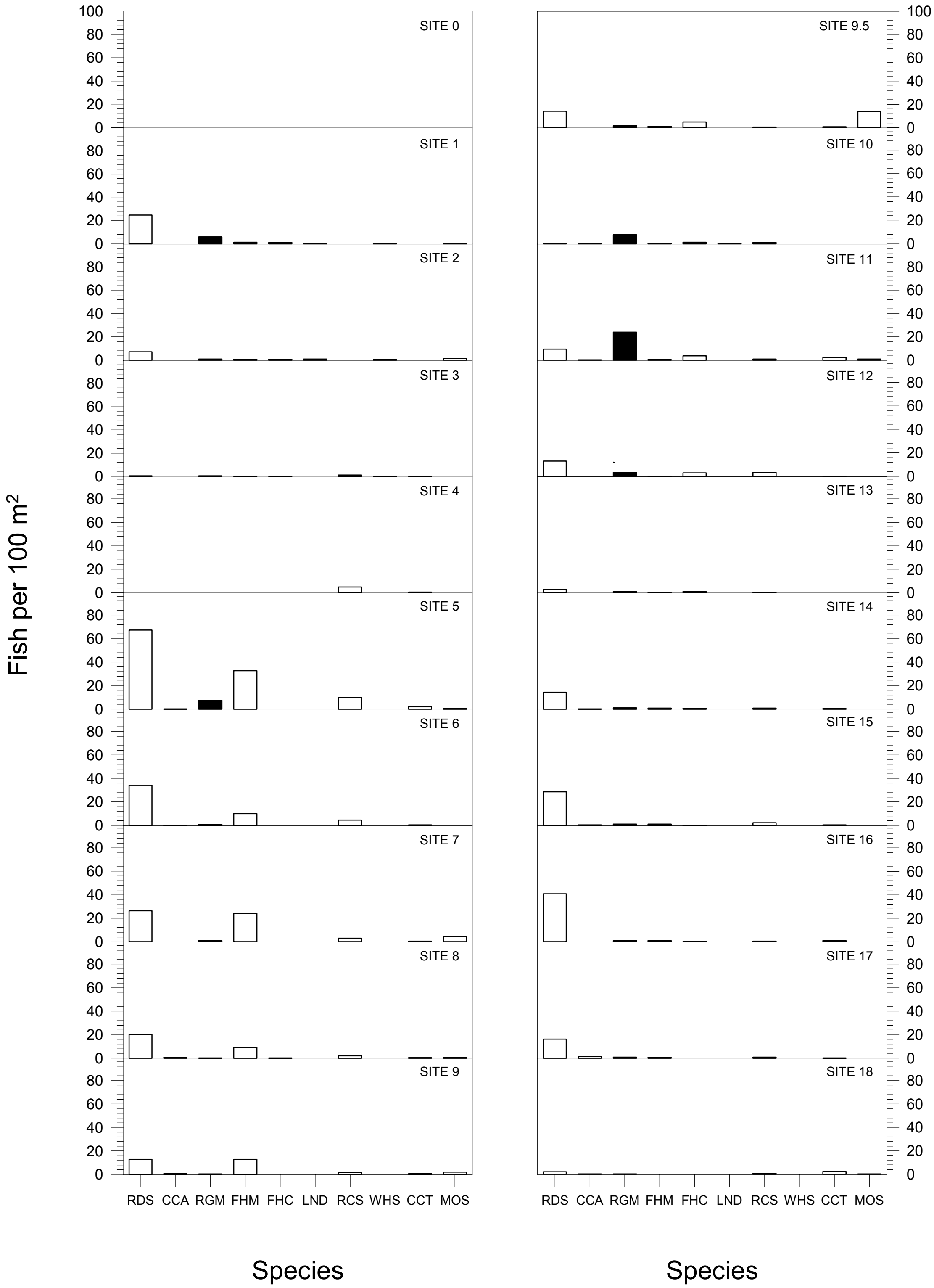

Figure A-2. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for February 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

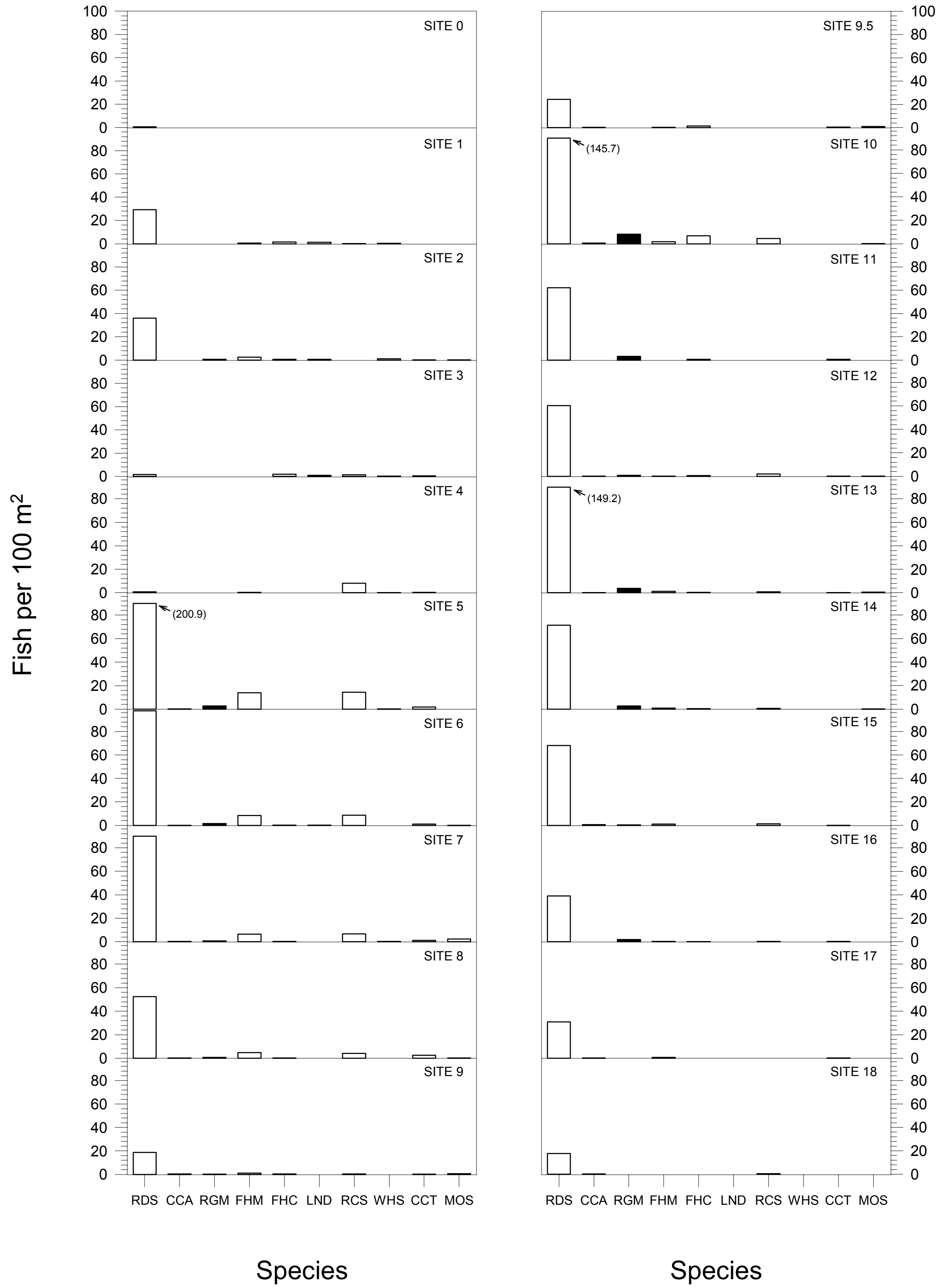

Figure A-3. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for March 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

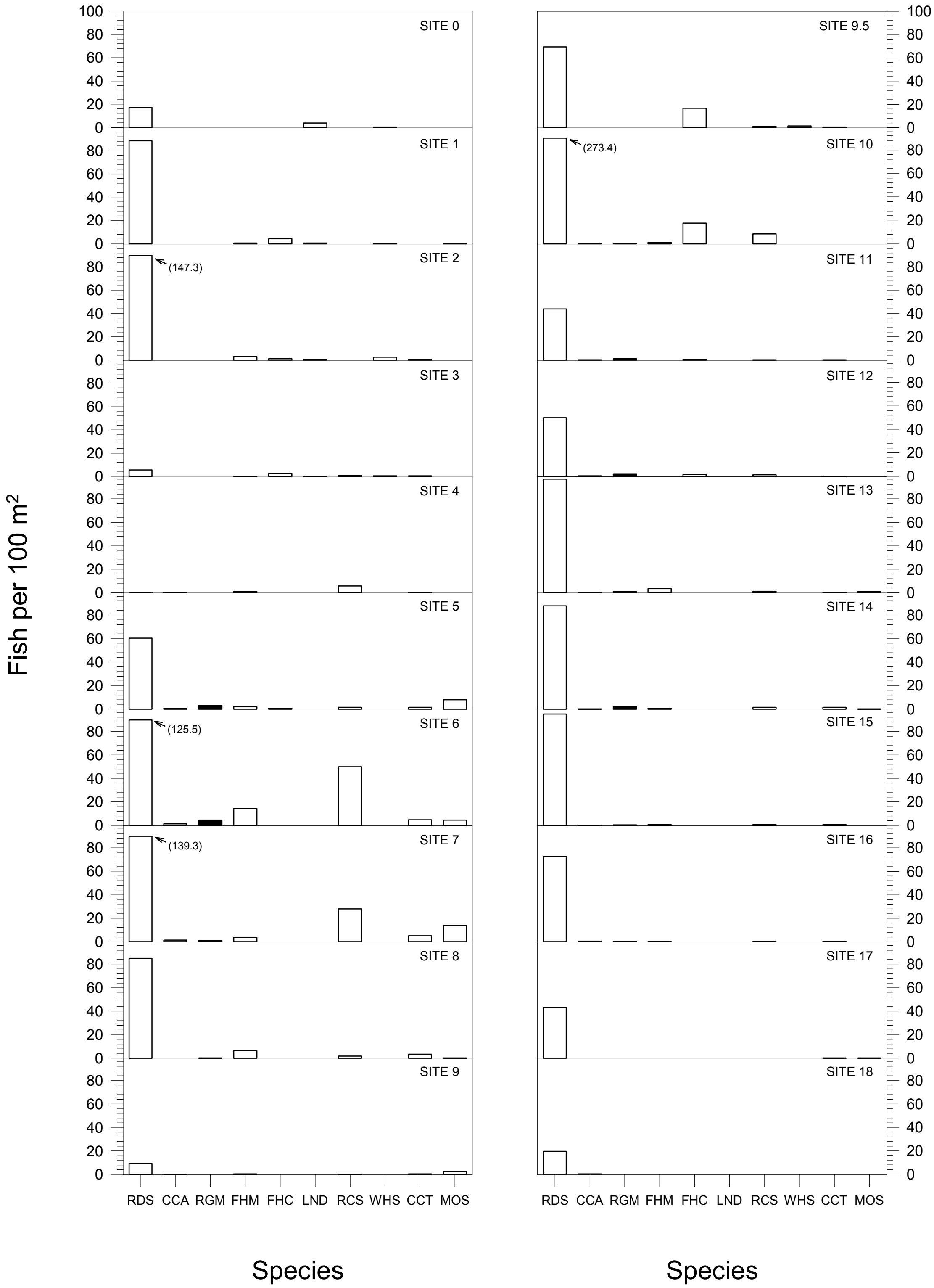

Figure A-4. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for April 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

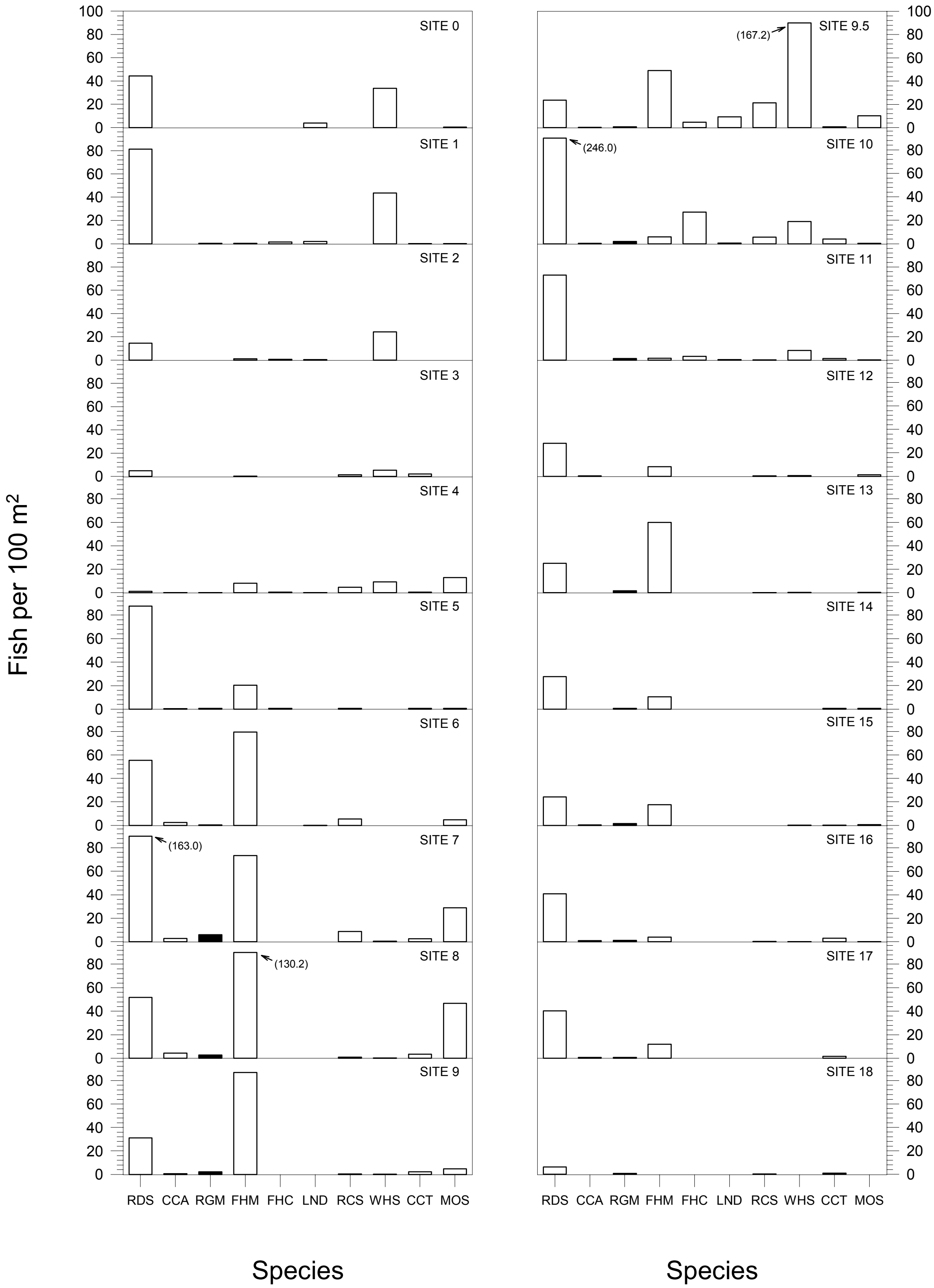

Figure A-5. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for May 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

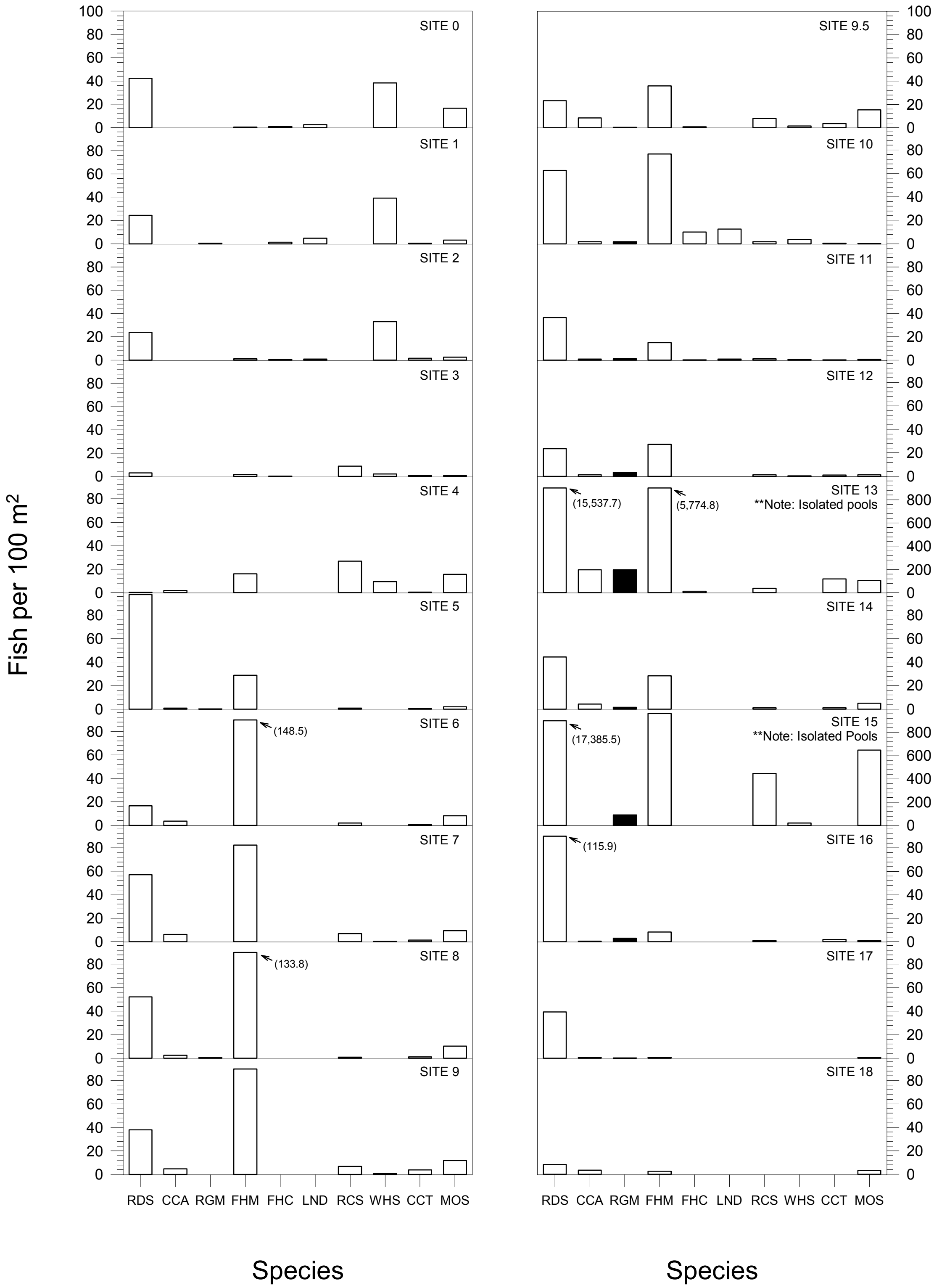

Figure A-6. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for June 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

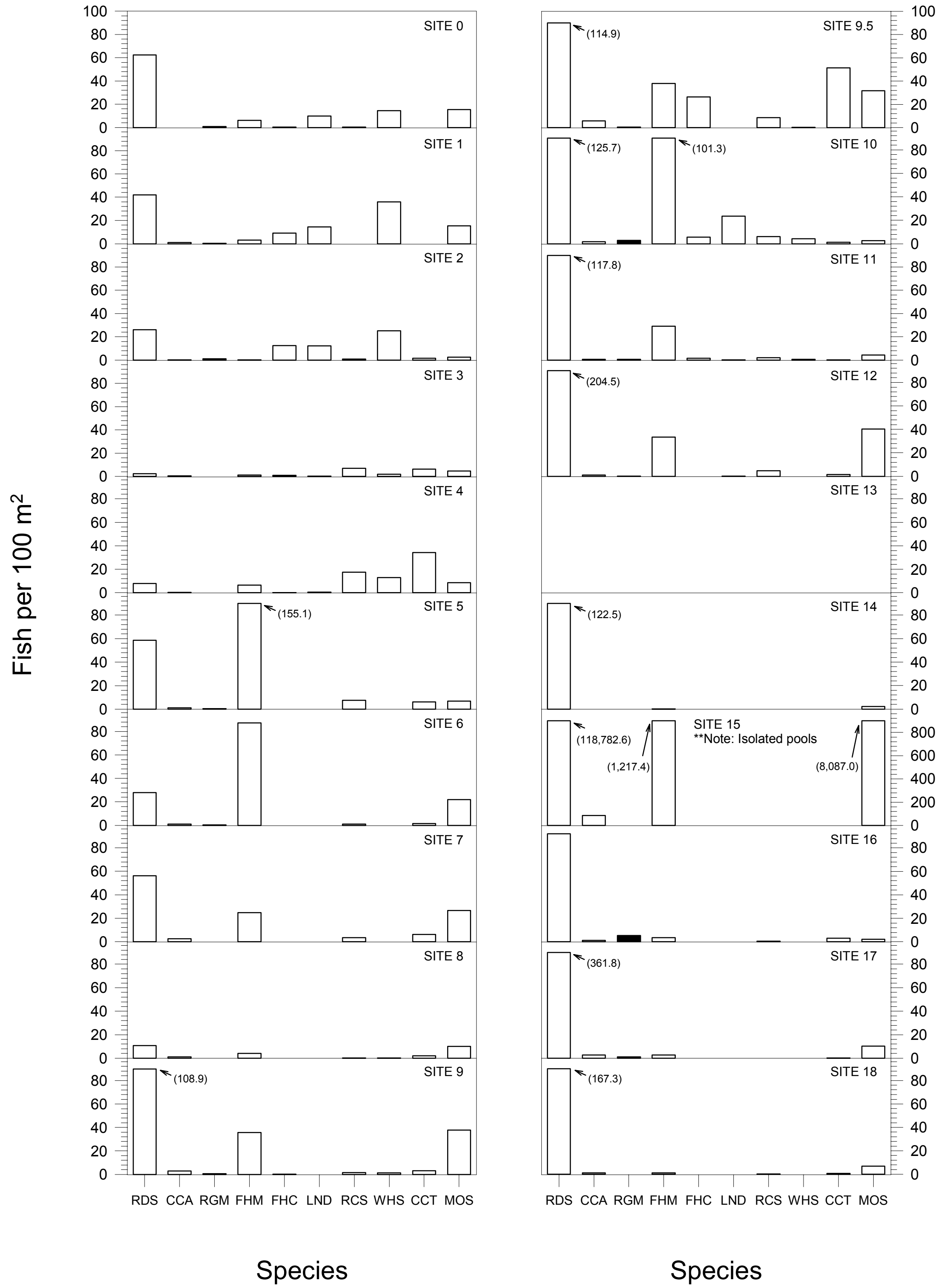

Figure A-7. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for July 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

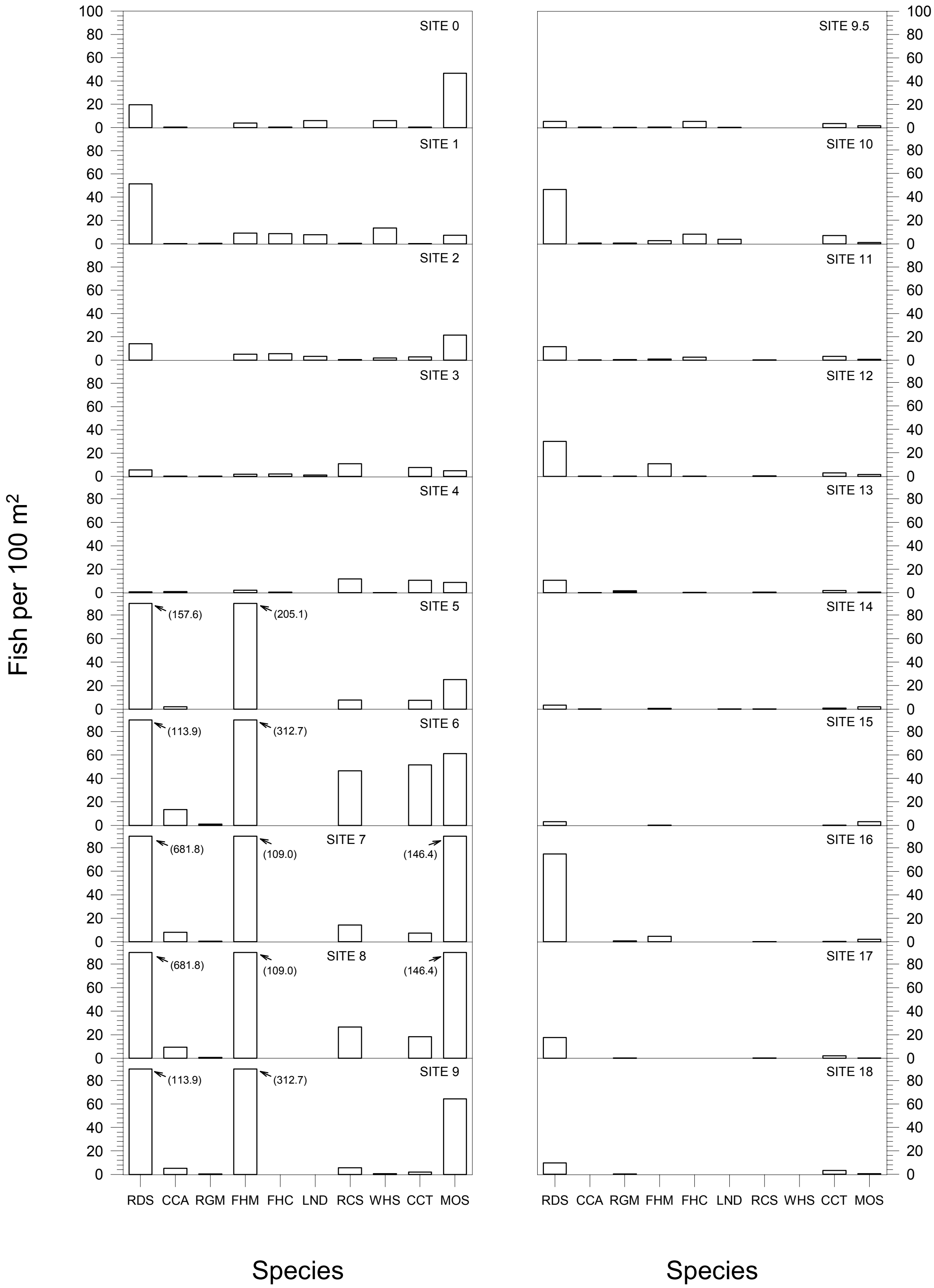

Figure A-8. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for August 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

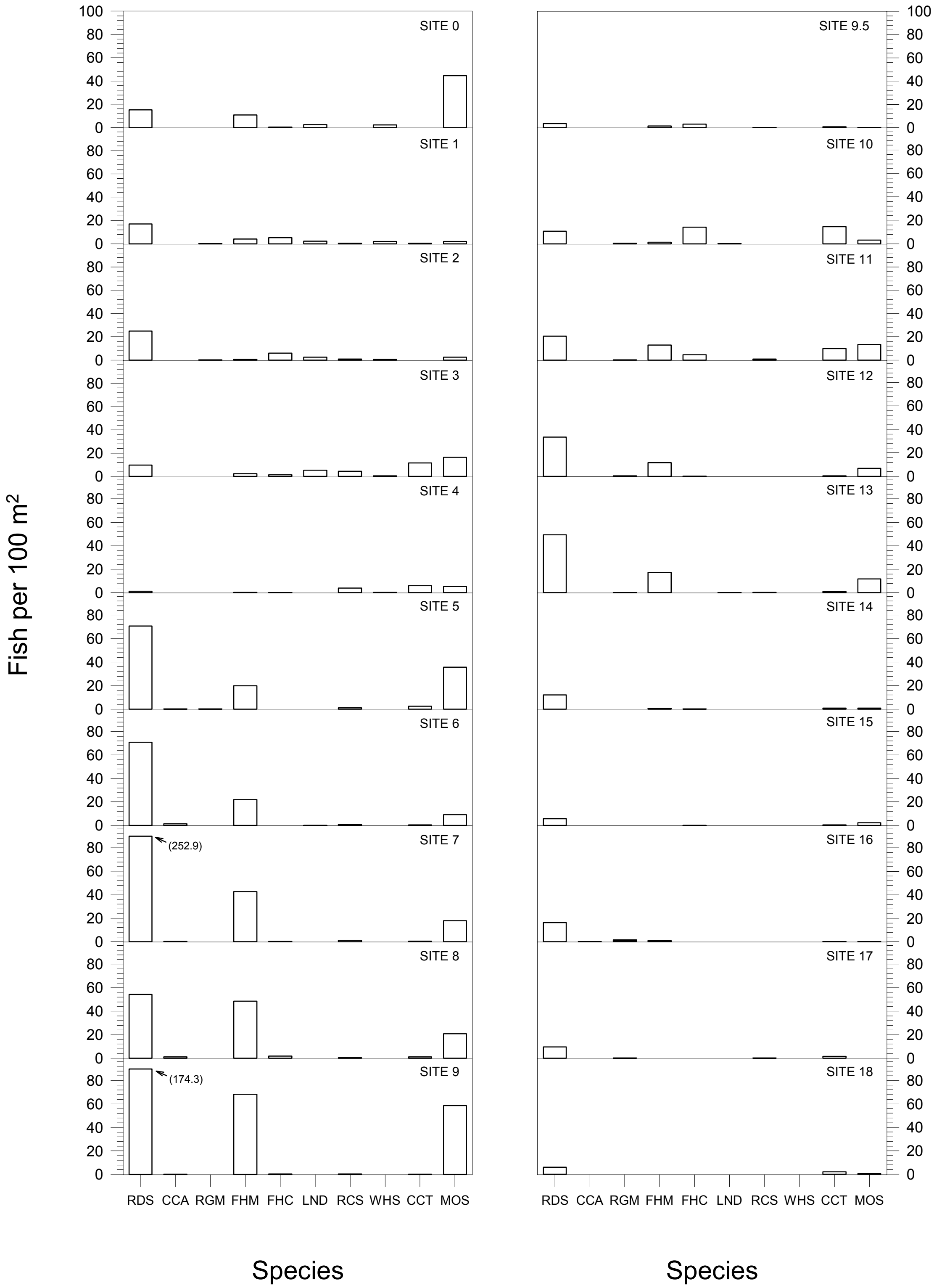

Figure A-9. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for September 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

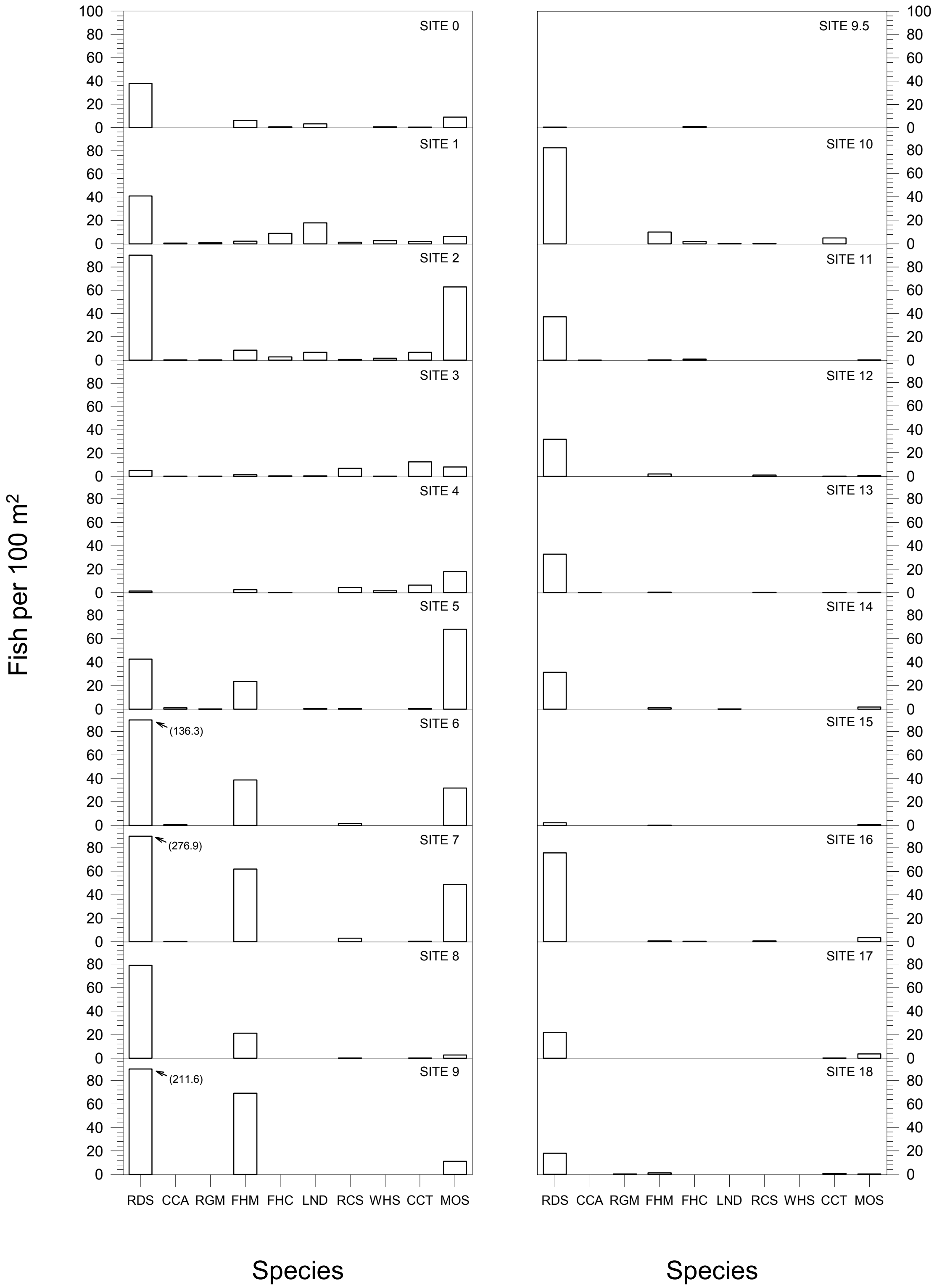

Figure A-10. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for October 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

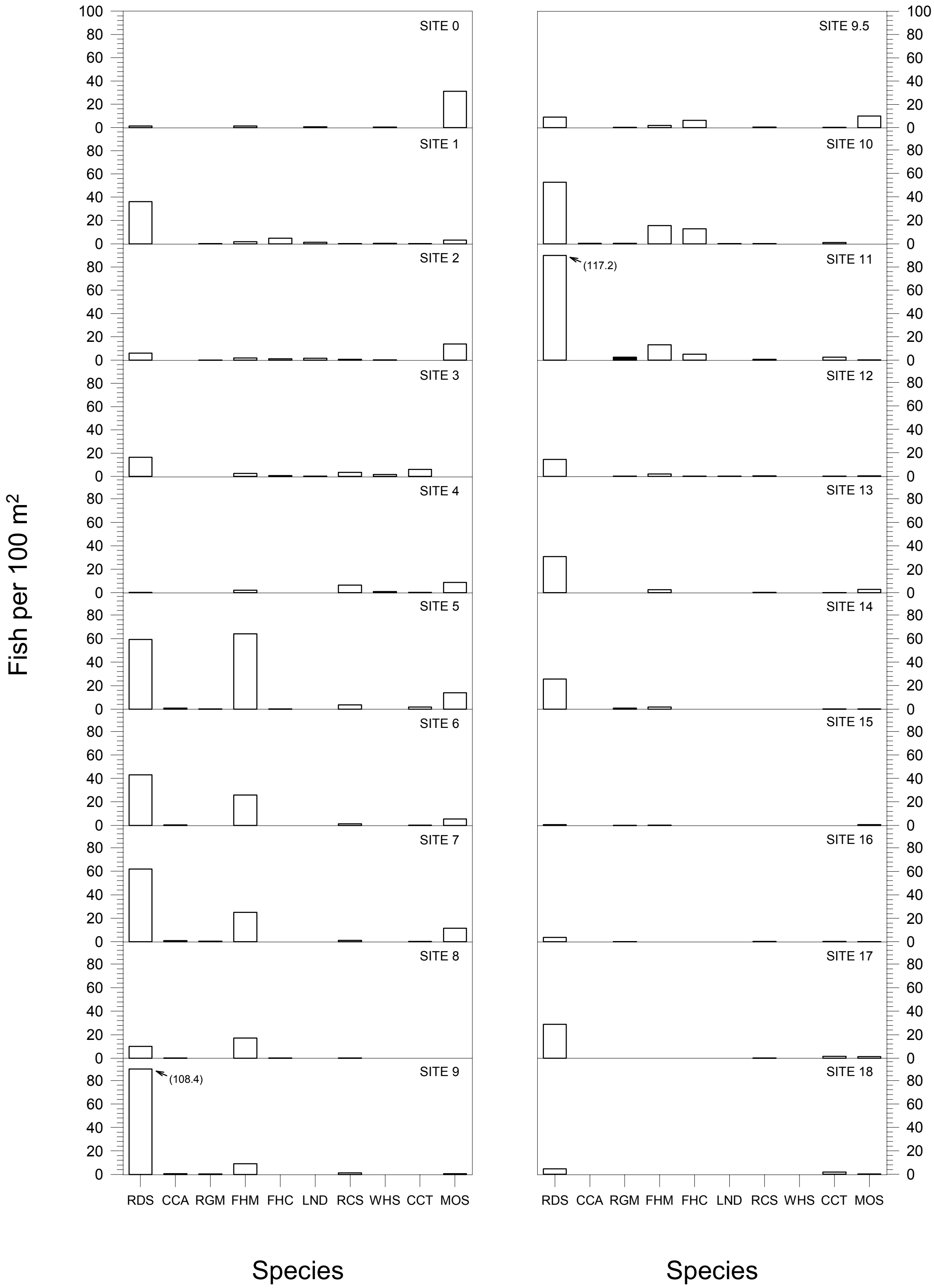

Figure A-11. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for November 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

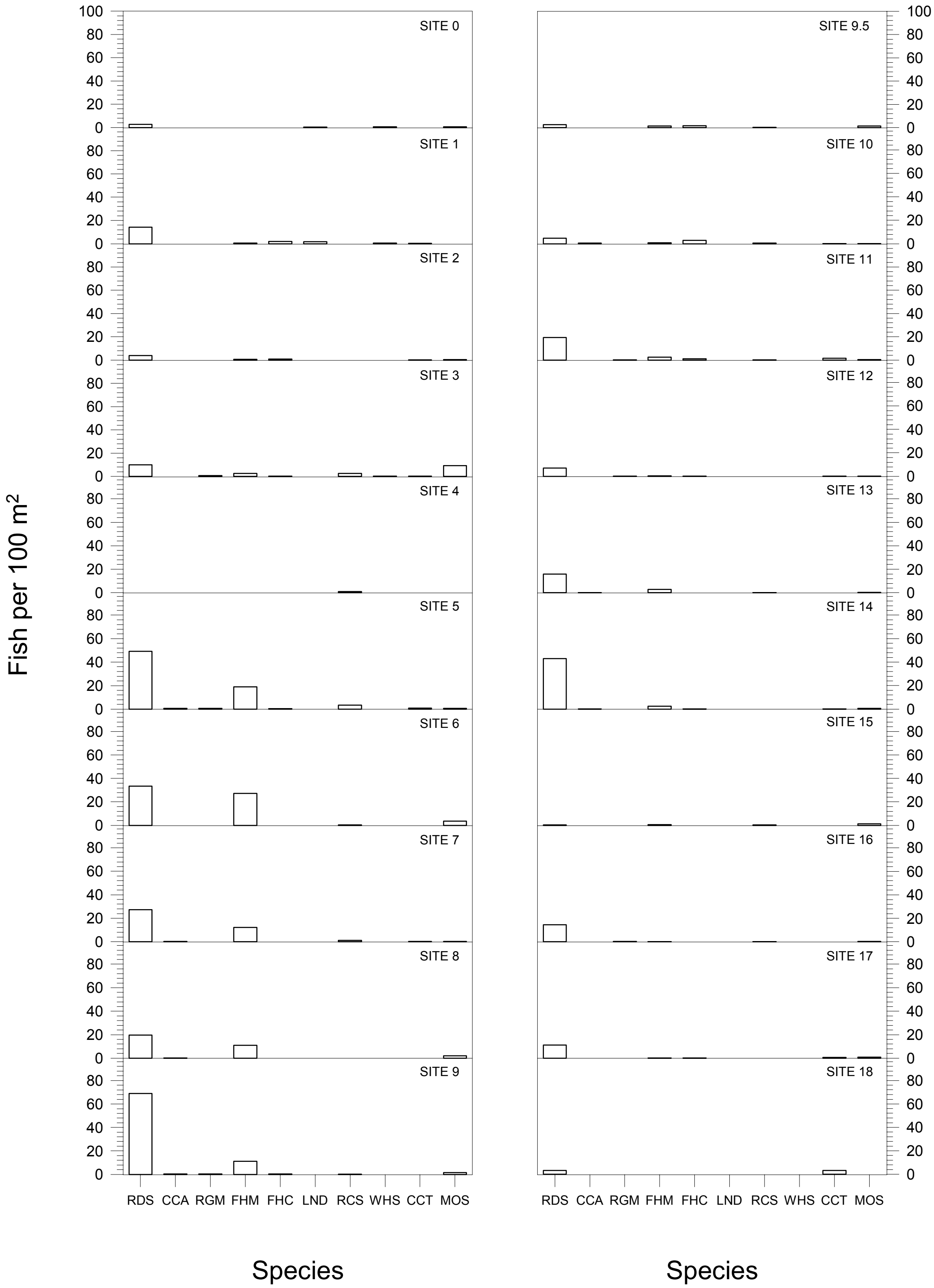

Figure A-12. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for December 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

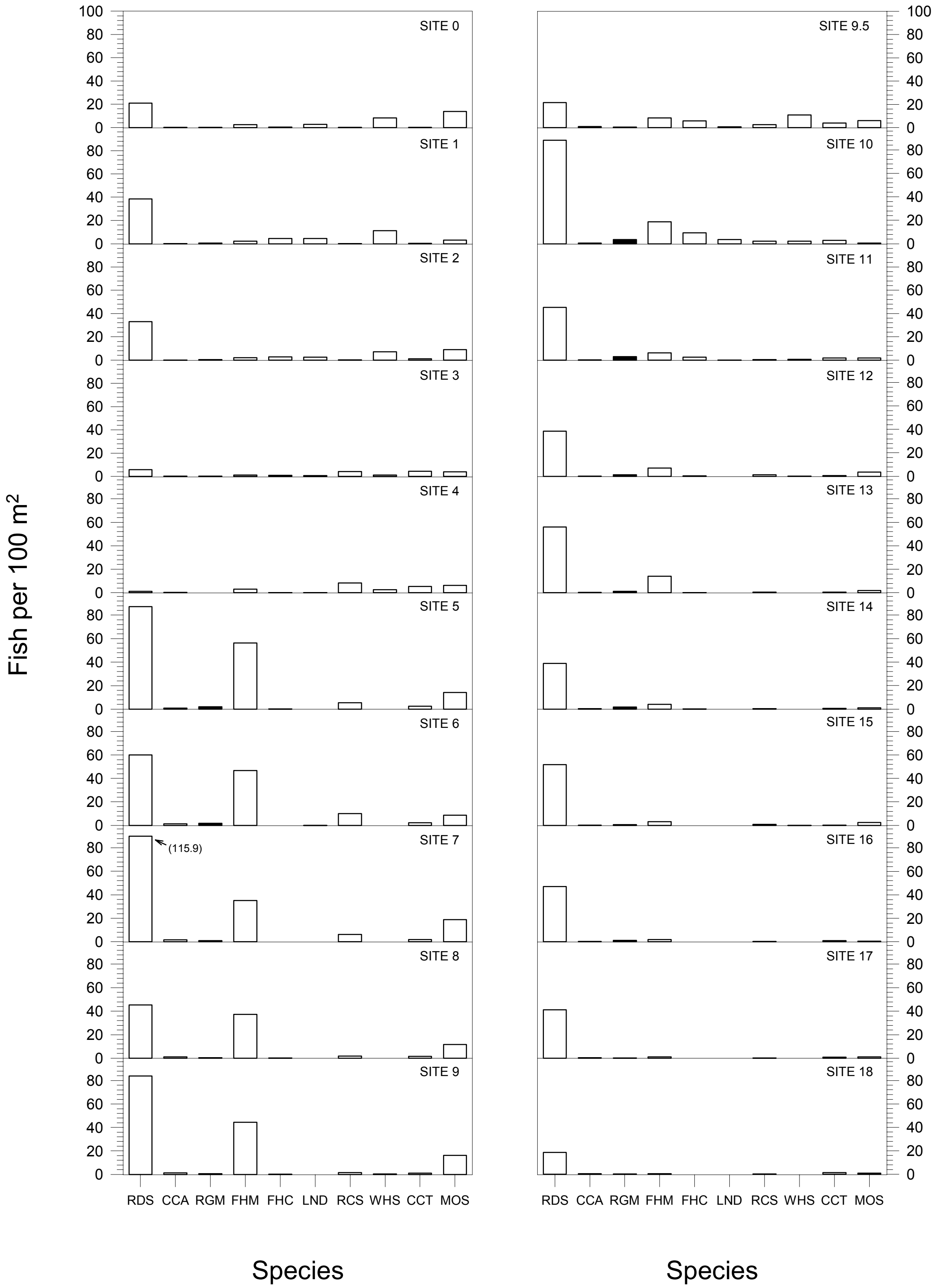

Figure A-13. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species codes) in the Middle Rio Grande for 2002. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

Appendix B.
Rio Grande silvery minnow population monitoring 2002

World-Wide-Web Cover Page

URL: http://www.usbr.gov/uc/albuq/envprog/rg/rgsm2002/index.html

Rio Grande Silvery Minnow Population Monitoring 2002

Monthly Fish Monitoring Data Reports:

- Most recent report: December

General Information about the Monitoring Sites

Site-specific data available on site pages below.

Rio Grande silvery minnow Spawning Periodicity Study and Egg Salvage Project Page (This project has ended for the 2002 season.)

Site-Specific Information:

Angostura Reach

- Angostura Dam
- Bernalillo
- Rio Rancho
- Central Ave. Bridge
- Rio Bravo Blvd.

Isleta Reach

- Los Lunas
- Belen
- Jarales
- Bernardo
- La Joya
- 0.6 mi upstream San Acacia

San Acacia Reach

- San Acacia Dam
- 1.5 mi downstream San Acacia
- Socorro
- 4 mi upstream 380 Bridge
- 380 Bridge
- Middle Bosque del Apache
- San Marcial
- Station 500
- Lower Corral

Credits

2000 Monitoring Data
2001 Monitoring Data

Appendix C.
Ichthyofaunal composition of the 2002
Rio Grande silvery minnow population monitoring collections [1]

Data are available at:
http://www.usbr.gov/uc/albuq/envprog/rg/rgsm2002/Fish_Data.html

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[1] The monthly 2002 fish collection data comprises about 120 pages and is not included in this hardcopy of the 2002 Rio Grande silvery minnow population monitoring report. It is, however, included in the electronic version of the report available at the above world-wide-web address.